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Experimental Chemiſtry:

BEING

AN ESSAY

towards reducing that branch of NATURAL PHILOSOPHY to a regular SYSTEM.

In nova fert animus mutatas dicere formas
Corpora ——————

By the Author of the Elaboratory laid open, &c.

VOLUME II.

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Experimental Chemiſtry.

PART IV.

Experiments, and obſervations, on the parts of vegetables.

CHAP. I.

General obſervations on vegetable ſubſtances.

THE component ſubſtances of vegetables, like thoſe of animal, might be diſtinguiſhed, as the object of experiment, in the moſt general view, into ſolid and fluid: but as many of them vary their form, with reſpect to theſe qualities, in different plants; or even in the ſame plant, at different times, and in different parts; and ſeveral of thoſe, moreover, which in ſome caſes make proper ſolid parts in particular kinds, are in others, or the ſame alſo, conſtituents in part of the fluids, it will be more expedient, to avoid repetition and confuſion of method, to diſtinguiſh them, in the experimental examination of their particular nature, into the FIBROUS or VASCULAR, and the SUCCULENT, or ſuch as are contained in, or excreted by, the vaſcular. There is, over and above theſe, another reaſon for this diſpoſition: which is, that all the ſubſtances, except that of the fibres, which make, in any caſe, proper parts of the vegetables, are either ſuch as enter at other times into the conſtituence of ſome of the fluid, or have a great proximity of nature to them: and conſequently fall under the ſame experimental conſideration; as agreeing with them in relation to their general properties, conſtituence, and decompoſition. It is therefore only neceſſary to enumerate them, in this light, as forming the proper ſolid parts of ſome kind of plants: leaving them, as the object of further diſquiſition, to the place they may hold as ſucculent parts, or ſuch as are either contained in, or excreted from, the fibrous or vaſcular ſolids.

All the parts of vegetables, as well the fibrous, as the ſucculent, appear, on their decompoſition, to be formed of the ſame elements with each other; and, indeed, with animal ſubſtances: and owe their diverſification only to different proportions and modes of original or mediate combination of them. Theſe elements are (as was before obſerved with reſpect to the animal ſubſtances,) the organical earth, phlogiſton, water, the acid proper to vegetables, and air: the three firſt, and the laſt, being ſenſibly diſcoverable in them, almoſt univerſally, on their decompoſition by heat: and the other being juſtly to be concluded, to have always ſome ſhare in their conſtituence, from the analogical neceſſity there ſeems to be of its preſence, to unite the other elements: it being found, as will be ſhewn experimentally in its proper place, that phlogiſton cannot be fixt, and conſolidated, without combination with acid of ſome kind.

The PROPER SOLID PARTS of vegetables may, alſo, like thoſe of animals, be diſtinguiſhed into the *organical*; by which, in this caſe, is to be underſtood only the vaſcular or fibrous, being of the ſame general nature in all plants, and every part of each;—and *certain ſecreted ſubſtances, which anſwer peculiar purpoſes in particular kinds only*. But theſe peculiar ſolid parts of plants are much more numerous, and various, than thoſe of animals: as, indeed, the whole œconomical ſyſtem of vegetables ſeems greatly more diverſified than that of animals.

The *fibrous* parts of vegetables appear not to differ from each other, when ſimply conſidered, though by the variation of contexture, and the effect of the different juices they contain, or the excreted ſolid ſubſtances conjoined with them, they are made to form parts extremely differing in denſity, tenacity, and rigidity, and other ſenſible qualities. But when ſeparated,

parated, from all the ſucculent ſubſtances, by maceration in water, and compreſſure, to free them from the ſaline bodies they contain,—and coction in the capital lye, or ſolution in water of the ſal ſaponarius, to extract the reſinous parts,—they appear to undergo the ſtricteſt experimental examination, without diſplaying any marks of difference; allowing for the compactneſs, or looſeneſs of texture, in which they may be wrought together, according to the fabrication of the various vegetables, or parts of them, they may have compoſed.

The fibrous parts of vegetables, being decompounded by heat, afford ethereal oil, water, earth, and air: and there is good reaſon to believe, that volatile alkaline ſalt is alſo, in ſome proportion, formed in the incineration of them, as well as of all other parts of animals and vegetables. But it is not to be obtained by diſtillation of them in cloſe veſſels. The nature of this earth, and of the volatile alkaline ſalts, having been fully inveſtigated before in its proper place; and there being a more expedient occaſion below for explaining that of the oil, it is unneceſſary to enlarge upon them here, as thoſe paſſages may be referred to.

The *excreted ſolid ſubſtances*, which make a proper part of ſome kinds of vegetables, are too various in their nature, in the different genera and ſpecies of plants, to bear a certain diſtinct enumeration: but thoſe that are moſt obſervable, are either *reſinous bodies*, which are found conſtantly, in ſome ſpecies, to envellop the buds of the leaves, or ſome of the parts of generation; ſerving as an involucrum to defend them from the injuries of the air, or the depredations of ſmall animals:—*concreted oils* repoſited in the nuts or ſeeds:—*wax*, which is found either as the baſis, or principal matter of the farina fæcundans; or in a more copious manner, in ſome American trees called the candleberry myrtle:—the *colorific matter* of the petals and ſtamina of many flowers, not being wax; as thoſe of the crocus, called ſaffron:—the *ſaccharine matter* which is found in the ſugar-cane, and other plants, conſtantly affording it in a concreted form in the interior parts:—ſome *gummous bodies* of the mucilaginous kind, which are found in the ſeeds:—and *camphor*. But theſe ſeveral ſubſtances, being, (as was above obſerved,) either the ſame with thoſe which are found, alſo, in a fluid ſtate, or ſimilar in their nature to them, will be particularly treated of in the place they hold in that view; and are therefore diſmiſſed from any further examination here.

The FLUID SUBSTANCES of vegetables (by which is to be underſtood, as was before declared, all ſuch as compoſe at any time the ſucculent parts of plants, though ſome of them may in their ſimple ſtate be properly conſidered as ſolid,) are extremely various; and thoſe kinds, which differ moſt from each other, are ſo linked by intermediate ſpecies, that it is extremely difficult to form ſuch a ſyſtem of diviſion, as will reduce the whole to proper genera: and ſome, moreover, are, in fact, only compounds of others. There is, however, in plants ſomewhat in each, that correſponds with the blood of animals; and from whence, all the other ſucculent bodies are ſeparated by proper ſecretory organs; and this is commonly called the *ſap* of the plant. But the analogy is not cloſe in ſome particulars betwixt the ſap or blood of plants and the blood of animals; for there ſeems to be generally more than one kind of this vegetable blood or principal ſuccus in the ſame plant: as, in many inſtances, two kinds of juices are found to iſſue on wounding the plant, in any part of it whatever that will at all bleed: of which juices, only one is found in ſome, and the other in different ſpecies; and that general reſemblance betwixt the ſuccus of different kinds of plants in colour and conſiſtence, which is found betwixt the blood of different animals, is alſo wanting. The moſt frequent forms in which the principal ſuccus of plants is found, may be conſidered as of three kinds; the AQUEOUS SAP, which principally conſiſts of ſaline and gummous bodies, and water, without any diſtinguiſhable matter of a ſulphureous nature:—the LACTEOUS SAP, which is formed of water, and a gummous ſubſtance imperfectly diſſolved; or a gummous ſubſtance perfectly diſſolved, with the ſuperaddition of a reſinous body imperfectly diſſolved in it:—and the SULPHUREOUS SAP, in which no water is ſenſibly perceived, and from which none can be extracted, but by the ultimate decompoſition through burning heat. Theſe ſeveral genera of ſap are to be recovered, by wounding the ſeveral reſpective plants; of which ſome afford their proper kind at particular ſeaſons, and in particular parts only; but others conſtantly, and from every part. There are, nevertheleſs, (as was above intimated) inſtances of ſuch as yield copiouſly both the aqueous and lacteous ſap; ſome in different parts of the plant, and others in all: which evincing, that theſe juices have each of them a diſtinct order of veſſels, that either form different members of the plants, or are commixt together throughout the whole, proves, therefore, that there are two diſtinct kinds of blood in the ſame plant. For one cannot be conſidered as the proper blood, and the other only as a juice ſecreted from it for particular purpoſes; becauſe each ſerves principally for the blood in different ſpecies. It is, however, probable, that moſt plants, eſpecially thoſe which form ligneous parts of a firmer texture, have, along with the aqueous ſap, ſome proportion of the ſulphureous, contained in a diſtinct order of veſſels complicated with the others throughout the whole of the plant: though the proportion in many kinds is ſo ſmall, compared to that of the aqueous, that it is not to be perceived in the ſimple experiment of wounding the plant. The aqueous and lacteous ſaps, analogouſly to the blood, are formed by mediate combination of ſome of the ſubſtances we ſhall below deſcribe in treating of the ſecreted juices; and are,

there-

therefore, eaſily analyzed, ſo far as to the recovery of the component ſubſtances ſeparately, without the ultimate decompoſition of the whole by heat or putrefaction. But the ſulphureous ſap is of a ſimpler nature, and ſimilar in all reſpects to ſome of the kinds of the ſecreted juices; admitting of no ſeparation into bodies generically different, but by ultimate decompoſition.

The AQUEOUS SAP is compounded, for the moſt part, of *water*;—*ſaline bodies*, which are the ſaccharine ſalt, the eſſential ſalts (before treated of, page 373, Vol. I.) and the proper Ammoniacal ſalts of vegetables;—and ſuch *gummous* or *mucilaginous bodies*, as are perfectly ſoluble in water: all which may be ſeparated, in general, from each other, by evaporation and chryſtallization; unleſs where minute quantities of ſalts are commixed with larger proportions of gummous or mucilaginous ſubſtances.

The LACTEOUS SAP may be obtained by wounding the plants of the thiſtle tribe, celandine, poppies, and many other kinds; and it is formed, in ſome few inſtances, of gummous bodies not perfectly ſoluble in an aqueous menſtruum; but more frequently of both gummous and reſinous bodies, and water; with either a greater or leſs proportion of all the ſaline matters, before enumerated, or of ſome of them. It is, therefore, eaſily to be analyzed, with reſpect to the water and gums, by ſimple evaporation: but the ſalts cannot be ſo ſeparated from it, becauſe the gummous parts elude the effects of chryſtallization, unleſs they be divided from the water; which may be effected by the addition of the precipitate earth of alum, to make the gum ſubſide.

The SULPHUREOUS SAP is formed of diſſolved reſins, united with ethereal oil, that flies off very ſoon when the ſap is expoſed to the air, and leaves, in ſome caſes, the reſinous matter incapable of being again diſſolved by any known menſtruum. This kind of ſap is afforded by ſeveral kinds of plants, but particularly abounds in many of the coniferous tribe: and in an extraordinary manner in ſome ſpecies of the toxicodendron or poiſon oak; which being cut with a knife, imparts to it a juice, at firſt not of a very thick conſiſtence; but which, ſoon drying, incruſts the knife with a hard varniſh, not eaſily to be taken off, even by ſcraping. The ſulphureous ſap being analyzed by heat, on the principle of incaleſcence, is ſeparable, by a degree leſs than that of boiling water, into a thin ethereal oil and reſin; but, by a greater degree, into a thicker oil, ſome acid lymph, and ſome proportion of earthy recrement.

The ſubſtances into which the three ſeveral kinds of ſap or principal ſuccus of plants are reſolvable by means of art,—or which are ſeparated from them by the action of their own ſecretory organs, with the mediation of air, heat, and light,—may be diſtinguiſhed into five knds; the *aqueous*, *ſaline*, *gummous*, *ſulphureous*, and *acid*.

By the AQUEOUS SUBSTANCE of plants is meant, water in its ſimple ſtate: which is the vehicle or fluid baſis of the tranſparent aqueous, and lacteous, ſaps; as it is alſo of many of the ſecreted humours. But, beſides the water found in plants under a fluid form, there is no kind of vegetable matter, the moſt ſolid and dry in appearance, of which it does not ſeem to make a conſiderable part, when ſuch matter is ultimately decompounded; not excepting even the ſulphureous kinds.

The SALINE BODIES that conſtitute, in part, the ſucculent juices of vegetables, are, moſtly, either *eſſential ſalts*, which are of a tartarous nature; or the *ſaccharine matter*. But *volatile alkaline ſalts*, likewiſe, appear evidently to be produced in a native ſtate, in the parts of ſome vegetables; as they are to be ſublimed from them by a leſs degree of heat than will make water boil; which is greatly leſs than what is ſufficient to generate them, by that combination of the component ſubſtances that follows the decompoſition by heat: of which inſtances are found in muſtard ſeed, onions, and moſt other kinds that have a pungent acrimonious ſmell.

Ammoniacal ſalts may alſo be juſtly preſumed, on good grounds, to be formed in ſome kinds: and there is even ſome ſlender foundation to queſtion whether the *lixiviate* may not ſubſiſt in others in a neutralized ſtate.

The ESSENTIAL SALTS, and SACCHARINE MATTER, are (as was ſhewn in the experiments on them) formed of the proper ſaline principles, united with oil, or ſuch elements as combine and form oil on the decompoſition of the ſalt by heat; and afford the ſame ſubſtances on their decompoſition by heat, as the tartar produced by wine: but, as the experimental nature of both has been before demonſtrated, it is needleſs to dwell longer on them here in that view. The eſſential ſalts of vegetables are to be obtained from different parts in different plants; and ſo is the ſaccharine matter: but the latter is frequently excreted from the leaves; and may be thence copiouſly obtained, either in an aqueous form or concreted. The ſarracena in Canada, is an inſtance of the ſecretion of ſugar in the leaves, remaining in a diſſolved ſtate; and the ſugar maple, in ſome other parts of North America, of its being found concreted; from both which plants attempts have been made to obtain ſugar in large. The ſaccharine matter, beſides its ſaline nature, has properties wholly peculiar to it: for, from that ſubſtance alone, is produced vinous ſpirits and vinegar by fermentation, as has been before explained, (p. 76, Vol. I.) in ſpeaking of that principle. On its decompoſition by heat in cloſe veſſels, it affords an acid lymph, ſome oil, and a greater proportion of coal, than gums or oils. Being ſubjected to heat, under the circumſtances proper for combuſtion, it flames, after the fire has turned the colour brown; and conſequently rendered the oil ethereal: and after the diſſipation of the other part, a ſmall portion of aſhes is left, which will be found to contain lixiviate ſalt. So that it appears to agree in its general nature with tartar and other eſſential ſalts; varying from them only in the proportion of the elements to each other.

The NATIVE VOLATILE ALKALINE SALT of vegetables, is principally found in the ſeeds and roots of thoſe which abound in it: but in ſome ſpecies it is, nevertheleſs, copiouſly diffuſed through the whole. It is obtained by diſtillation with a leſs heat than boiling water, which raiſes it, together with part of the aqueous fluid of the plant: from whence it may be recovered by repeated rectifications; or, more eaſily, by combination with acid, and, after a due evaporation, departure, by means of fixt alkaline ſalts, or chalk, according to the proceſs of Experiments XVII and XIX. Section III., Part II. Volume I. The preſence of volatile alkaline ſalts in plants, is a cirumſtance of variation in them, from the nature of animals; and affords a paradox. For it is never found in any of the proper parts of animals; though, from obvious cauſes before explained, produced conſtantly in a conſiderable quantity in them; while, on the contrary, in ſome vegetables, where there appears no means of its production, it is found copiouſly. But the explication of this difference will lead perhaps to the accounting for its preſence in vegetables, in a native ſtate. For, in animals, the volatile ſalt being generated by the putrid action of the whole maſs of blood, which would be deſtructive of the due craſis, if not conſtantly controlled by the preſence of acid, nature has conſequently provided, that ſuch acid ſhould be always ready in the maſs to that end; either as introduced in the air abſorbed by the lungs, or generated by the fermentation of aceſcent diet; and the volatile ſalt is, therefore, neutralized as ſoon as formed. But in vegetables, where we may, to preſerve the juſt analogy, conclude it to be generated likewiſe by putrefaction, it is reaſonable to ſuppoſe the ſeat of that putrefaction, which produces ſo great a copia of volatile alkaline ſalt, does not lie in the whole maſs of ſap, but in ſeparate humours, repoſited in diſtinct veſſels; where the effect not being deſtructive to the general œconomy of the plant, and neceſſary to the end of the particular part, the volatile alkaline ſalt is ſuffered to ſubſiſt in its proper unneutralized ſtate; and, moſt probably, is concentrated by means of ſecretion, before it be lodged in the repoſitories where we find it ſo greatly abounding, as in the ſeeds of muſtard, and ſome other ſubjects. But there are yet other circumſtances attendant on the nature of ſuch plants as produce native volatile ſalts, which confirm the opinion, that they are produced here, as in all other inſtances, (except ſuch as are foſſile,) by putrefaction. If thoſe parts of vegetables which yield volatile alkaline ſalts by a degree of heat leſs than that of boiling water, having been deprived of the whole of the quantity that can be extracted by theſe means, be afterwards urged by the degree that will make the ultimate decompoſition of animal and vegetable

table ſubſtances, a further quantity will be afforded, and in a conſiderable proportion: which laſt quantity is apparently generated in the combuſtion; ſince, if they exiſted before in the plant, they would have been raiſed with the leſſer degree of heat before given, which was fully ſufficient to that effect. It alſo appears on the incineration of ſuch parts of vegetables, that they produce no fixt alkaline ſalts. From whence, when the difference betwixt fixt and volatile alkaline ſalts (as before explained and verified by Experiment IV. Part II.) is conſidered, it reſults that theſe parts of vegetables greatly abound in exalted oils, or phlogiſtic matter, brought by putrefaction to that ſtate, moſt apt to their combination with the other ſaline principles for the production of volatile alkaline ſalts. Becauſe the ſaline principles, which produce the volatile alkaline ſalts, would, without the preſence of ſuch exalted oil, produce fixt alkaline ſalts: and this property of affording volatile, inſtead of fixt alkaline, ſalts, will be found, on examination, to extend not only to all thoſe parts of the plants which yield the native volatile ſalts, but likewiſe to the whole of ſuch plants. It can, therefore, be ſcarcely doubted, but that the native volatile alkaline ſalts in vegetables are the effects of putreſcence, analogouſly to their generation in all other caſes; though in ſome inſtances, no ſign of putrid fœtor appears attendant on them in the plant: which may be accounted for, either by the ſmall quantity of the putrefying parts, or by the change, that may be made in the oil exalted to that degree, in conſequence of its combination with acid; for which nature may have made ſome proviſion here, as well as in the caſe of animals.

The AMMONIACAL SALTS, if at all exiſting in them, do not abound in ſuch quantity in the juices of plants, as to be eaſily ſeparated in a collected ſtate from them; and they are, therefore, only to be obtained, by ſublimation, out of the ſoot of ſuch as have been burnt: nor can it, moreover, be concluded, that all ſuch as are found in the ſoot really exiſted under that form in the plant. For it may be juſtly preſumed that a part of them are produced from volatile alkaline ſalts formed in the combuſtion; and which meeting with the acid that is copiouſly ſeparated in this decompoſition of moſt parts of the vegetables, may combine and form with it Ammoniacal ſalt. But that ſome proportion of them is formed in the plants without combuſtion, can ſcarcely be doubted; when it is conſidered, that both volatile alkaline ſalt, and acid, the two elements of Ammoniacal ſalts, are in many inſtances demonſtrably preſent in the juices of the ſame vegetable.

The LIXIVIATE, or vegetable fixt alkaline, SALT, though producible only from plants, cannot be properly enumerated among thoſe, that exiſt in the juices: there being great room to doubt whether it be not always, generated, (as was before obſerved,) in the decomcompoſition effected by heat. There is, however, one fact which points out ſome foundation of doubt, whether they do not exiſt, in a combined ſtate, with oil and acid, in ſome of the eſſential ſalts of plants: which is, that eſſential ſalts and tartar, being acted upon in cloſe veſſels, by the burning degree of heat, will afford them, without the aid of any combuſtive action: which ſeems to indicate, that they make a proper part of the eſſential ſalts, or tartar; and require only to be ſet free from the acid and oil, by their being made to act on each other. If this be allowed, it infers, that the lixiviate ſalts were produced in the juices of the plants: and the reaſon why they are not found there, may lie in their being combined with the other principles; and deprived, conſequently, of their alkaline character, as ſoon as generated: in the ſame manner, as volatile alkaline ſalts in the blood. It is not, however, demonſtrable by any experimentum crucis, whether the eſſential ſalts and tartar be compounds of lixiviate ſalt already formed, and combined with the acid and oil after its formation: or whether they be only conſtituted of ſuch elements, as are capable of forming the lixiviate ſalt with the aid of heat, but not already combined in that ſtate: and therefore this peculiarity in them, of yielding lixiviate ſalt without incineration, or the *combuſtive* action of heat, leaves the matter extremely dubious. But whether fixt alkaline ſalts exiſt, or not, in the vegetables, before they undergo the action of heat, it is evident, that the ſucculent parts, without the fibrous, are capable of producing them; becauſe they are obtainable, not only from tartar copiouſly, but likewiſe from extracts made by coction from thoſe vegetables which afford them: and it is equally true, that the fibrous parts will not produce them without the aid of the ſucculent, even by incineration; as the fact itſelf appears in an experimental trial, either on thoſe which are wholly diveſted of the ſucculent parts; or on thoſe not ſo diveſted, but where the elements were originally wanting in the ſucculent parts. It is certain, likewiſe, that there is an unfitneſs to produce lixiviate ſalts, even in the parts of ſome plants containing the elements of them, that is equivalent to the abſence of ſuch elements: for by converting them into volatile alkaline ſalt, the ſame defect of the fixt alkaline is cauſed, as if the elements of them were wanting: and it is certain, that where volatile ſalt is formed, there are the elements of the lixiviate; as it has been before demonſtrated, that the latter is convertible into the former. This unfitneſs is occaſioned (as was obſerved before) by the abundance of phlogiſtic matter in a certain ſtate, which is not only found in ſome particular plants, but in hotter countries, in a certain degree, in all: as has been diſcovered in the trials to make potaſhes in various parts of North America.

The GUMMOUS SUBSTANCES, are bodies ſoluble in water; to which they give an unctuouſly, or viſcidly, tenacious conſiſtence; or ſometimes thicken it as gelatinous bodies: but, being freed from the water, they concrete into a ſolid maſs of a conſiderable degree of hardneſs; which is nevertheleſs in general tranſparent. They differ characteriſtically from ſalts, (beſides what regards their conſtituence,) in not concreting into maſſes of any regular determined figure; and from reſins, in not being ſoluble in ſpirit of wine; nor of ſo ſulphureous a nature, as to burn, through accenſion, without being previouſly decompounded by the action of heat. For, as they contain no eſſential oil, they cannot be accended till they be burnt black; that is, till their conſtituent oil be rendered ethereal by the action of heat. There is, however, a conſiderable variation in the qualities of gums, with reſpect to their ſolution in water. For ſome diſſolve perfectly; and only give, as it were, an unctuoſity to water; as the gums Arabic, and Senegal, and thoſe afforded by the plumb, cherry, and other trees, in our own country: while others give a mucilaginous ropy texture; as that of the marſh-mallow, and the ſeeds of quinces: and a third kind ſeem only to have an imperfect combination with the water; and, either form a milky ſolution, like the native lacteous juices of plants, as the gum Ammoniac; or, in other inſtances, appear not to be reduced to abſolute fluidity by their union with the water, as a diſſolved body, but to imbibe it; and ſwell, with it, into a kind of gelatinous body; as the gum tragacanth. The gum Arabic, and others of that kind, are, alſo, ſoluble in ſubſtantial oils, with the aid of heat. Gums differ, alſo, in colour: the greateſt part being white; as the Arabic, Senegal, &c; and the others yellow; as that extracted from the French berries, and various parts of many vegetables. The ſubſtances of this kind, eſpecially the more perfect gums that only give to water an unctuous viſcidity, are very reluctant to putrefaction; and will preſerve their intire nature a long time, even though in a diſſolved ſtate. They ſuffer, however, at length, a decompoſition, on this principle, in the ſame manner as the fibrous parts of vegetables, to which they ſeem nearly allied in their conſtituence, though they contain ſomewhat more oil, and a yet greater proportion of acid, and water. Being decompounded by heat, on the principle of incaleſcence, they afford a copious lymph, that is ſomewhat acid;—ethereal oil, but in a much leſs proportion than reſins;—and coal, in a much greater. According to ſome, they yield, alſo, volatile alkaline ſalt; but it does not appear to me, from experiment, that there is any ground for this aſſertion. On their being ſubjected to heat, with the acceſs of air, they do not (as was above obſerved) accend or take fire, as reſins, till they be, in ſome degree, decompounded by the action of the heat: and then, after flaming moderately, and glowing for a ſhort time, aſhes are left; which, beſides the earth, contain lixiviate ſalt. Gums are produced in various parts of plants; and in ſome kinds throughout the whole; but others are wholly devoid of them. They ſeem therefore, on the whole, to be allied in their qualities to the gluten in animals; and, in ſome manner, they are ſo in their application likewiſe, but never ſolely ſerve for the ſame end. For, as the ſap or blood is twofold in many kinds of plants, ſo is the gluten alſo: ſince, beſides that kind, which gives coheſion to the earth conſtituting the fibres, and which is not ſoluble in water, or any other known menſtruum, without the intermediation of a greater heat than will make water boil, there is another kind in moſt ſpecies, that ſerves to conjoin the fibres with each other, and give them due rigidity and compactneſs; and which is ſometimes of a gummous, and ſometimes of a reſinous nature: as will appear from the coction of different kinds in water; where ſome will be found to loſe their tenacity and hardneſs, and others to retain it.

The SULPHUREOUS BODIES, which make a part of, or are produced by, the ſucculent juices of plants, are the moſt various, and moſt important claſs of all thoſe afforded by vegetables: as in them, moſt generally, the medicinal virtues of the plant reſide; as well as other qualities, which render them applicable to many uſeful purpoſes: and it is, therefore, expedient to be particularly minute with reſpect to them; eſpecially as the different ſpecies of them, vary extremely from each other.

In order to the comprehending the properties of the ſulphureous parts of vegetables, it is previouſly neceſſary to underſtand, in ſome de-

degree, the general nature of ſulphureous bodies: and I ſhall, therefore, as it has not before been explicitly touched upon, explain as much as is neceſſary to the particular ſubject in queſtion: reſerving all further diſquiſition on it, till it be treated of in a diſtinct light.

All ſuch ſubſtances, as may be deemed of a ſulphureous nature, have for their eſſential character, that they will, when heated to a certain degree, with the acceſs of air, burn, from the heat generated in themſelves, till their whole ſubſtance be conſumed or diſſipated: leaving either none, or but a very ſmall quantity of aſhes or recrement. This quality in ſulphurs reſults, from their having a larger proportion, than other bodies, of phlogiſton in their conſtituence: which gives them their combuſtibility; and volatizes that portion of earth they contain. Sulphurs are conſtituted of this phlogiſton, combined with acid, and ſome proportion, always, of earth and water. The phlogiſton, which is, of its own nature, rarefiable, and conſequently volatile, in an extreme degree, is conſolidated, and fixed, by the acid: and the earth ſeems to be only the medium of the combination of the other elements, and not, otherwiſe, eſſential to the nature of ſulphur. But to the different proportions of the earth is, nevertheleſs, owing, in part, the degree of fixity, and moſt of the other great variations in the kinds of ſulphurs from each other. The ſpecies of ſulphureous bodies produced by vegetables, which are all that are proper to be taken into conſideration here, may be divided into *oils*, *ſpirits*, *reſins*, *balſams*, *gum-reſins*, and certain *anomalous kinds*. To theſe, may alſo be added, the *fixt ſulphur*, remaining with the earth in the coal, after the decompoſition of the parts of vegetables, by heat on the principle of incaleſcence: but as this kind is never ſeparable, nor by experimental means perceptible, unleſs in ſuch coal; it is not abſolutely determinable whether it exiſts in the ſame ſtate before, or be generated from combinations of the other ſubſtances, or their elements previouſly decompounded by the action of heat. From the black colour, however, which is always attendant on it in the coal, and of which there is not the leaſt appearance in the intire ſtate of the parts of the plant, there ſeems greater reaſon to conclude, it does not exiſt till after that change, in the whole ſyſtem of combinations, be made, which the heat produces: and conſequently that it is not a part of vegetables in their natural ſtate.

OILS are ſulphureous bodies, either of a fluid conſiſtence; or of a concreted form, becoming again fluid, by means of gentle heat. They are rejective of commenſtruation with water, without the mediation of a third kind of body; and conſume, when ſubjected to the due heat, under the circumſtances neceſſary to combuſtion, almoſt wholly in flame or ſmoke. Theſe are the properties common to all oils; but there are others peculiar, as we ſhall ſee below, to particular ſpecies. In their being either of an unctuous, or perfectly fluid, conſiſtence, they differ from balſams, reſins, and foſſile ſulphurs; in their rejecting combination with water, from ſpirits; and in their conſuming, when burnt, almoſt wholly in flame or ſmoke, from all other ſubſtances but thoſe. Oils appear to be formed, as other ſulphureous bodies, of phlogiſton, acid, earth, and water, in that proportion, as to the phlogiſton, which conſtitutes them ſulphureous: for the preſence of this body, in ſuch proportion, is demonſtrated by their combuſtive property: and the acid, water, and earth, are to be ſeparated from them by decompoſition through heat. But by what peculiar mode of combination, or by what relative proportions of the elements, they differ from other ſulphureous bodies, is not diſcoverable by experiment: though it is evident, that they owe a principal part of their difference from them, as well as from each other, to the proportion of acid, by which the phlogiſton is controlled and fixed. The oils to be obtained from vegetable ſubſtances may be divided, as well as thoſe obtained from animals, (on the principles before laid down in ſpeaking of thoſe of animals,) into *ſubſtantial* or *fat*; and *ethereal:* of which laſt, ſuch as are in a native ſtate are called *eſſential*; and both theſe kinds are found, in ſome inſtances, naturally in a fluid; and in other, in a concreted form: though it is not frequent to find the ſubſtantial oil of vegetables in a concreted ſtate, unleſs rendered ſo by addition of ſome other body, or by decompoſition. The difference of ſubſtantial from ethereal oils, beſides their unctuous conſiſtence, is generally placed (as was before obſerved in ſpeaking of thoſe produced by animals) in their different volatility: the ethereal oils being capable of riſing with a heat leſs than that of boiling water; and the ſubſtantial oils requiring a much greater degree, or a conſiderable length of time, to their exhalation; nor is it then to be effected without ſuch a decompoſition, as converts them to ethereal. But the ſubſtantial oils are, nevertheleſs, all capable of being converted into ethereal, by that exaltation, which they undergo through the action of heat or putrefaction: and which, in fact, ſeems to be, by the freeing the phlogiſton from part of the acid and earth, with which it is combined; and which reſtrains its volatility and rareſcence. Repeated diſtillations, conſequently, ſeparating it in a greater degree from thoſe two bodies, render the oil ſtill more ethereal, that is, more fluid and volatile, till only ſuch a proportion of them remains, as the phlogiſton can raiſe with leſs force than over-balances the attraction by which they are united. In the firſt diſtillation of ſome kinds of ſubſtantial oils, a conſiderable quantity of acid is ſenſibly ſeparated; and, in all, a greater or leſs proportion of coaly matter, containing neceſſarily the redundant earth: which demonſtrates evidently the difference of the conſtituence, betwixt ſubſtantial oils, and the ethereal, which riſe with a ſufficient degree of heat in their whole ſubſtance. But there is, moreover, another clear characteriſtic of difference betwixt ſubſtantial and ethereal oils: which is, the capacity of the ethereal to burn with the acceſs of air, when accended by the contact of any other body of the luminous degree of heat: a quality wanting in the other, till rendered ethereal by the action of the heat on it. For, if ſubſtantial oil be poured, in a ſufficient quantity, on burning bodies, it will extinguiſh them in the ſame manner as water: as may be gathered from the obvious fact of the impracticability of lighting a candle, when the unburnt tallow has ſmeared the wick, till ſuch time as the oil be burnt brown by the action of heat; in which caſe the oil is rendered ethereal. The reaſon of this reluctance to combuſtibility, in ſubſtantial oil, ariſes from the phlogiſton's being rendered leſs attractive, with reſpect to the nitrous acid, in this ſtate, by means of its combination with another acid; from whence that rapidity of motion in the commenſtruation, which generates the heat, and is the foundation of combuſtion (as was before obſerved, page 57, Vol. I. in explaining that principle), is checked in ſuch a manner, that the effect, which ſhould conſtitute the combuſtion, is not produced. It is, therefore, neceſſary, that the phlogiſton ſhould be ſeparated, in ſome degree, from the other acid and earth, by heat, or putrefaction, before it can combine, with due force, on the nitrous acid:

to which, even the increaſe of the volume, from the redundant proportion of earth and acid, is another cauſe of retardation: as they ſet the really active particles at a greater diſtance from each other's attraction; and abſorb the generated motion: preventing, conſequently, the accelerating effects of the colliſion or attrition.

There is, however, a conſiderable variation in ſubſtantial oils, with reſpect to this point: ſome receding ſo far from the moſt fixt ſtate of oleous bodies, as to ſuffer a decompoſition quickly, when expoſed to the air, with a very expanded ſurface, without any putrefaction, or the application of heat: the moſt volatile part evaporating; and leaving the reſiduum in a ſolid concreted maſs, greatly tenacious; while the others never ſuffer ſuch a decompoſition, in exhaling, as to produce a ſolid body; but remain in their original fluid ſtate, till diſſipated by the abſolute putrefaction of the whole, or by a burning heat. Inſtances of the firſt kind are found in the oils of walnuts and poppies; and of the latter, in thoſe of olives and almonds. But it is not in this property alone, that the leſs fixt ſubſtantial oils verge on the nature of the ethereal: for they, moreover, have a conſiderable mutual attraction with acids; being rendered leſs neutral, from the want of that greater proportion of acid in their own conſtituence, which gives the fixity to the other kind: and indeed, in this particular, they approach ſo near to the nature of ethereal oils, that, being ſuddenly commixt with concentrated ſpirit of nitre, the mixture will explode with great force and heat; as will be found on ſuch commixture of oil of walnuts, with that acid.

VEGETABLE SUBSTANTIAL OILS are, as has been before intimated, always more fixt than water: and not to be decompounded ultimately, but by that degree of heat, which decompounds all animal and vegetable ſubſtances; or by putrefaction. Like other oleaginous bodies, they are not ſoluble in water, without the mediation of alkaline ſalts; nor perfectly, without the ſal ſaponarius: but being combined with that, in the form of ſope, as, by a proper treatment, they freely unite with it: and, in this ſtate, they alſo combine with ſpirit of wine, to which they are otherwiſe rejective of attraction; and they even retain that quality, when again ſeparated by departure, through acids, from the alkaline ſalt. They combine, by the mediation of heat, with mineral ſulphur: and alſo with lead: forming with the firſt a tranſparent brown, and with the latter a white opake body. Being decompounded by heat, on the principle of incaleſcence, they afford ethereal oils of a ſtrong ſcent, very volatile, acrid, and fluid: a ſmall proportion of coaly matter being left behind. Being urged with heat, under the circumſtances proper to combuſtion, they waſte away in flame and ſmoke, leaving ſome little portion of aſhes: as is well known by their uſe in lamps. Thoſe which are more allied to the ethereal kind, are reluctant to putrefaction; but, in length of time, grow more tenacious, or concrete, if kept in a cloſe veſſel; or, if expoſed to the air, undergo a decompoſition of a peculiar kind, as will be ſhewn below in an experimental view. The others ſuffer a rancid putrefaction, being expoſed to the air in a gentle heat; but in a much ſlower manner than the oils of animals: as both the difference of the fœtor, and length of time required to their diſſipation, make apparent. Subſtantial oils are moſtly afforded by the fruit, or ſeminal parts of vegetables: from whence they are obtained by preſſure, trituration, and coction with water.

ESSENTIAL OILS are more volatile than water; acrid; odorous; capable of burning when accended by the contact of any body heated to the luminous degree; for the moſt part fluid, with little or no tenacity; and of leſs ſpecific gravity than water: though there are ſome kinds, as thoſe of cloves and Jamaica pepper, that are ſomewhat unctuous, and heavier conſiderably than water; and others that concrete into a ſolid form, when cold, as the oil of roſes. They vary in colour in different ſpecies of vegetables: ſome being white; moſt a browniſh yellow, or red; and a few blue. They vary, alſo, in their conſiſtence, as to craſſitude or tenacity: ſome being thin, and incoheſive as water, others viſcid or unctuous: and, in general, the thickeſt are the heavieſt; but this does not prevail conſtantly: for the oil of ſaſſafras exceeds moſt others in weight, and yet is thin as water. The volatility of eſſential oils bears, therefore, no conſtant proportion to their conſiſtence: but it will be found to have relation to their ſpecific gravity: the heavieſt being the moſt fixt: though this is far from being a conſtant law with regard to the ſpecies of other genera of bodies. By their volatility and property of burning away when accended, they are conſidered as a ſpecies of the *ethereal oils:* the other ſpecies of which are, the oils to be extracted from foſſile bodies; and thoſe produced by the decompoſition of ſubſtantial oils, or other animal or vegetable bodies by heat: but in their native and intire ſtate, they are not wholly conſtituted of ethereal oil, but contain likewiſe a portion of the odorous ſpirit of the plant; of which, the nature will be ſhewn below in its proper place. Eſſential oils are for the moſt part combinable with ſpirit of wine and ſubſtantial oils; but rejective of water: they diſſolve many reſinous bodies, though not all promiſcuouſly; and combine with alkaline ſalts, and ſulphur; alſo, with concentrate acids, in ſome inſtances, with ſuch celerity, that exploſions enſue the ſudden commixture. Being ſubjected to heat in cloſe veſſels, they riſe; but not wholly, unleſs urged by a ſtrong degree: for ſome proportion of recrement is generally left behind; and ſome proportion of acid and water ſeparated at the firſt and ſecond diſtillations: and if alkaline ſalts, or earths, be added, that decompoſition is greatly promoted: and, in many inſtances, the peculiar or ſpecific qualities of the oil deſtroyed. A partial decompoſition is alſo ſuffered by diſtillation with vinous ſpirit: for the odorous ſpirit of the plant, and the more volatile or exalted part of the oil, riſe with the vinous ſpirit; and leave the more fixt in a reſinous form. They may likewiſe be deprived of the odorous ſpirit by commixture with water. On being accended, by the touch of any body luminouſly hot, the air being ſuffered to have acceſs, they are wholly diſſipated in flame. They are not ſubject to putrefaction, but in an extreme ſlow degree: being too ſimple in their compoſition to admit of a ſtrong fermentative action in their parts; and therefore being expoſed to the air, the more exalted part exhales, and leaves the remainder in a dry reſinous form. This is not, however, the caſe of the groſſer ethereal oils, extracted from animal ſubſtances; for they ſuffer a much higher degree of putrefaction: as is too often ſeen in the genuine ſpirit of hartſhorn; which, on keeping, grows turbid, brown, and fœtid, though with a ſcent peculiar to the burnt oils of animals. Eſſential oils, being ſuffered to ſtand at reſt for a long time, concrete, for the moſt part: or at leaſt acquire a greater degree of viſcid tenacity than they had at firſt. This ſtate may be again changed for that of the original, or a greater degree of fluidity, by a rediſtillation: which has always the conſtant effect, of rendering thoſe that are of a thicker conſiſtence more fluid, and leſs tenacious; ſo that the moſt concreted may be rendered fluid by repeated diſtillations;

lations; but not without greater or leſs diminution of their quantity, by the recrement left in the veſſel from which they are raiſed. But if, as generally happens, the peculiar ſcent, or flavour, be loſt by the avolation of the odorous ſpirit, which is generally a concomitant circumſtance, when eſſential oils thicken with age: the rediſtillation will not repair that defect; but rather augment it.

Eſſential oils are produced in various parts of vegetables: ſome affording them from their root; others from their fruit, wood, bark, or indeed any part whatever, or the whole of the plant. They are to be ſeparated from the parts of the vegetables that afford them, by expreſſion; or by diſtillation, to which the matter affording them may be ſubjected either *per ſe*, or with the addition of water; and likewiſe by extraction, through the diſſolving power of ſpirit of wine, with the aid of gentle heat.

SPIRITS are ſulphureous bodies formed of phlogiſton combined with acid, and ſome proportion of earth and water. They are combinable with further quantities of water; and, being not too much diluted, are capable of burning as ethereal oils. They differ, nevertheleſs, from ethereal oils, in commenſtruating with water: but in other reſpects ſeem to be ſtrictly allied to them. The word ſpirit has indeed been applied to other bodies of very different kinds: as particularly the acid eſſences, and ſolutions of volatile alkaline ſalt: but thoſe ſubſtances being of a very diverſe nature, and not agreeing in one ſingle generical characteriſtic with theſe, or with each other, it may juſtly be regarded as an abuſe of the term: ariſing, with moſt others of the ſame kind, from the crude and indiſtinct notions, which the early cultivators of chemiſtry entertained. The bodies I have claſſed under this term, being of the nature of ethereal oils, and yet combining with water, properly form a genus: and, having been uſually called ſpirits, may, with great propriety, be continued under that name; excluding all other ſubſtances from it, but thoſe which, like them, are of the nature of exalted oils, but yet capable of commenſtruating with water. The ſpirits, according to this ſenſe of the term, producible by vegetables, may be divided into the *odorous ſpirits*, *vinous ſpirits*, and *oleous ſpirits*. The firſt, and laſt, of which, differ eſſentially in almoſt every kind of plant; and, in many inſtances, in the different parts of the ſame plant: but the other is abſolutely the ſame, from whatever plant, or part of plants, it be obtained, when in a pure ſtate.

The ODOROUS SPIRIT of vegetables, called by Boerhaave *ſpiritus rector*, after the alchemiſts, is that body, to which the whole, or particular parts, owe their peculiar ſcent; and indeed their flavour likewiſe, when not owing to acid, or ſaccharine matter; and which probably anſwers ſeveral other purpoſes in the vital œconomy of the plant, not diſcoverable by obſervation and experiment.

It is extremely volatile, perhaps to a degree much greater than that of any other compound body cognizable by us. From whence, and from its apparent affinity of nature with the fœtid ſpirit raiſed in putrefaction, or the other bodies that properly come within the denomination of ſpirit, it may juſtly be concluded to be a ſulphureous body, in which the phlogiſton is in a ſtate leſs controlled, and fixt, by combination with acid and earth, than in any other ſubſtance, except the exalted oil of putrefied bodies: that obtained from ſpirit of wine, under the name of ether, being obviouſly leſs ſo. There may be ſtrong reaſons, moreover, drawn from analogy, in ſupport of the concluſion, that the odorous ſpirit is a compound, in which the ſulphureous principle chiefly prevails; which is, that phlogiſton is the inſtrument of nature, in every other inſtance, of the production of ſcents: as will be found on obſervation. This extraordinary body ſubſiſts, as there is reaſon to believe, in every part of the plant: but it is, in a greater degree, abundant in the flowers, and eſſential oils: though found, in ſome inſtances, in the leaves, roots, and fruit. It is not, however, conſtantly of the ſame character, with reſpect to flavour or odour, in every part of the ſame vegetables: but ſeems to vary in itſelf frequently, with reſpect to thoſe qualities, in different members of ſome plants; beſides the modifications it undergoes, by having its effect combined with that of the other juices, with which it may happen to be commixt. This ſubſtance may be ſeparated, from the parts of the plants which afford it, in a combined ſtate with water, by diſtillation; and, in a combined ſtate, with oils, by infuſion in ſuch oils: but it is of too volatile a nature, to admit of being collected in a pure ſtate: on which account, it can be brought to the teſt of ſuch examinations, as might give a further light into its nature. All, therefore, that is known, more than was obſerved of its being the medium of the peculiar ſcent of the reſpective kinds of plants, or their particular parts, and of its volatility, is, that it combines with oils, either ſubſtantial or eſſential; that it is more ſtrongly attracted by water, which will deprive them of it, by due means of commixture; and ſtill more ſtrongly by air, to which it quickly flies from the water, if their communication be not effectually prevented, by incloſing the water, impregnated with it, in veſſels ſtopt in the moſt ſecure manner.

I have rejected the name of *ſpiritus rector*, given by Boerhaave, after the alchemiſts, to this ſubſtance, in order to prevent that miſconception, which might be produced by the uſe of it, in conſequence of the hypothetical notions, advanced by them, and adopted by him, relating to the ſubject: notions not warranted by experiment in ſome particulars, and in others contrary to the obvious ſtate of the fact. For he intimates, that the odorous ſpirit is the ſame, or ſimilar, in the whole of each plant, uniting all the parts of it under one character, or rather giving one character to them all, with reſpect to ſcent, and flavour; whereas nothing is more evident, in a great multiplicity of inſtances, than that the different parts of the ſame plant greatly vary, with reſpect to theſe qualities; and not in ſuch manner only, as may ariſe from the admixture of one ſimilar ſpirit of this kind, with the other bodies that conſtitute the juices in each of the reſpective parts, but eſſentially with regard to the ſcent and flavour of the ſpirit itſelf. This may be ſeen in many ſpecies, where the root, and flowers, differ, in theſe points, in the moſt oppoſite manner, that can be conceived: having not the leaſt of any thing reſpecting them in common: and the ſame, in ſome caſes, of other parts with each other. It is inſinuated, likewiſe, that the odorous ſpirit is of a perpetual nature; not deſtructible, nor diſſipated in conſequence of its being ſeparated from any particular plant, even by the ultimate decompoſition of ſuch plant, but reſuſcitating again, in a new individual, when it meets with proper matter to which it may ſerve as a fæcundating principle. But all this, with the analogy of the odorous ſpirit to a ſuppoſed ſimilar kind, in animals and metals, which he touches upon likewiſe, are notions, that ſtand without any baſis of experimental proof, or induction from ſufficient data; but ſeem to be adopted, by this repromulgator of them, from a prepoſſeſſion in favour of the Archæus of Van Helmont, ens appropriatum of Paracelſus, and

other

other parallel myſteries of the adepts: for which kind of metaphyſical fruits of the wild imaginations of the alchemiſts, he ſhews, on many occaſions, a very ſtrong taſte.

VINOUS SPIRIT is equally volatile with the moſt ethereal oils, except that which is to be obtained from it; and agrees with them in all other particulars, but in its being ſoluble in water, diſtillable without reſiduum, by a leſs heat than will make water boil, incapable of concretion, or any other change of its nature, when ſecured from the admiſſion of other bodies, and decompoundable in a peculiar manner by the addition of the vitriolic and nitrous acids. It is conſtituted, as may be evinced by its decompoſition, of ethereal oil, of which ſome part is extremely exalted, and the other in a groſſer ſtate, with a proportion of acid, water, and earth; and they are ſo combined, that heat ſimply, that is to ſay, without the mediating addition of other bodies, cannot ſeparate them: for even in the combuſtion of this ſpirit the earth is volatilized with the other parts, not the leaſt reſiduum being left. Spirit of wine diſſolves ſeveral reſins, but not all; as alſo camphor, flowers of Benjamin, and ſope. It commenſtruates with moſt ethereal oils, water, and acid: but rejects ſubſtantial oils, and ſalts; except the neutral ſalt, formed by the combination of lixiviate ſalt and vinegar. But with reſpect to ſalts, this muſt be underſtood of it in the purer ſtate, when it is called *alcohol*: for when more diluted, the water combined with it will diſſolve ſome proportion of ſalts, without quitting the ſpirit, unleſs in the caſe of the lixiviate ſalt; which, when added, departs the ſpirit in a great proportion from the water. Vinous ſpirit cannot be decompounded by heat, on the principle of incaleſcence, (as was above ſaid) without the addition of ſome other body: but, by the commixture of the vitriolic and nitrous acid, ſuch acid as well as the ſpirit being in a concentrate ſtate, it is decompounded; yielding then, by a gentle heat, an ethereal oil, the moſt volatile body of any hitherto known that can be collected, in a pure ſtate; which is ſeparated from the water and acid: and a groſſer oil, fixt by the vitriolic acid added, which together conſtituted the ſpirit. The ethereal oil, ſo formed by the decompoſition of the vinous ſpirit, which is called *ether*, and the *ethereal ſpirit of Frobenius*, is extremely volatile: to ſuch a degree, that being let fall in drops in a warm room, it is diſſipated in vapour, before it can reach any body placed under the veſſel at a ſmall diſtance. Its combuſtive diſpoſition is likewiſe ſo ſtrong, that being brought near to any flame or burning body, its vapour takes fire; and propagates it to the maſs, which inſtantly conſumes in flame, with a celerity almoſt exploſive. It rejects commenſtruation with water: but combines with gold diſſolved in aqua regia; and with the reſins and gums of moſt kinds of plants. Being decompounded by heat on the principle of combuſtion, vinous ſpirit is wholly inflammable: and that part of the vapour, which may be condenſed, is found to be merely aqueous.

The ANOMALOUS SPIRITS produced by vegetables ſeem to be, in fact, only eſſential oils combined with ſome other body, that operates as a medium in rendering them capable of commenſtruating with water, as well as with vinous ſpirit: which quality ſeems alone to diverſify them from ſuch oils; which they reſemble in all other points. As they are not to be extracted from the plants which produce them, without a proportion of water, they are not to be obtained in a pure ſtate; as their ſolubility in it eludes the end of diſtillation; which is the means by which ethereal oils and vinous ſpirits are ſeparated from other ſubſtances: and this conſtant union with water prevents their being ſubjected to due examination with regard to their nature. There is a variety of kinds of theſe ſpirits: but there is one ſpecies in particular, which is found in the ſame plants diſſimilar to each other; and even in very diſſimilar parts of thoſe plants. This is that ſpirit which is diſtilled from laurel leaves, and alſo from the kernels of black cherries, peaches, and ſeveral other kinds of fruits. This kind of ſpirit is of an extremely poiſonous quality to ſuch a degree, that when not too diluted, it gives inſtantaneous death to the largeſt animals, who ſwallow even a very ſmall portion of it. It reſembles, as well in this quality, as in the ſmell and bitter taſte, the eſſential oil of bitter al-

almonds; inſomuch, that one may juſtly conclude it to be the ſame kind of ſubſtance, only united with ſome other body, capable of acting as a medium in combining it with water. There is another kind of ſpirit, which is to be found in the greateſt proportion in galls; but ſubſiſts likewiſe in ſeveral other parts of vegetables. This has the quality of decompounding vitriol diſſolved in water, and rendering the mixture of a black colour: but this property is not owing to any aſtringency, as is generally taught; nor is it peculiar to this ſpirit, being to be found in other exalted oils. There is another remarkable kind, of a very different nature from theſe; which is that afforded by pepper-mint: and it is of a peculiar nature, as well in its ſingular flavour, attended with a ſenſation of coldneſs in the mouth; as for its extraordinary medicinal virtues.

RESINS differ from eſſential oils, in being of a ſolid form; and ſo fixt, as not to riſe with heat till decompounded by it: they appear to be of the ſame conſtituence; but with a larger proportion of acid and earth, though much leſs than in ſubſtantial oils: for they will burn when accended by the contact of any body newly heated. They are ſometimes of a red, and ſometimes of a yellow colour; but moſt frequently of a white ſomewhat verging to the yellow. They have various degrees of hardneſs; ſome being extremely brittle, and others approaching to the firmneſs of amber. Many of them are ſoluble in ſpirit of wine; ſome in eſſential oils; and a few in the putrefying whites of eggs: but they vary from each other greatly in relation to their attraction with thoſe ſubſtances: ſome, as the maſtic, and ſanderac, being ſoluble in both; ſome, as that of the turmeric root, in ſpirit of wine only; and others, as one of the kinds of thoſe called gum animi, in neither. They are in general ſoluble in ſubſtantial oils; but never in water, without the mediation of volatile alkaline ſalts; and, in ſome caſes, of the ſal ſaponarius only; the ſolution of which is the only menſtruum in ſeveral inſtances, that can be uſed for extracting them from the parts of the vegetables that afford them. It appears from experiment, that they differ in their conſtituence from eſſential oil, principally in having a larger proportion of acid joined to the phlogiſton; beſides ſome exceſs, likewiſe, in the proportion of earth; from both which, being in part freed, by the action of heat, they become ethereal oils. In their reſolution, therefore, by heat, either on the principle of incaleſcence or combuſtion, they are decompounded in the ſame manner as eſſential oils; excepting that the recrement of coal or earth, they leave, will be in a greater proportion. In ſome kinds of reſins, which are neareſt in their nature to thoſe of the pine and fir trees, a very ſmall recrement is found in the veſſel after diſtillation; nearly the whole riſing in oil of different degrees of ſpiſſitude, and an acid lymph, which accompanies the oil to the laſt, notwithſtanding the degree of heat required to raiſe it. Theſe kinds of reſins conſequently conſume in flame on their combuſtion, without leaving aſhes, unleſs in a very minute proportion. Reſins are produced as the gums, in very various parts of the reſpective vegetables: ſome in the fruit, others in the wood, root, or indeed almoſt any other part whatever: and they require, therefore, very various means to extract them. Many are to be collected in a native ſtate; that is, exuded ſpontaneouſly from ſome parts of the plant: others require, that the plant ſhould be purpoſely wounded by inciſion or puncture: but the far greateſt part require either the uſe of ſome menſtruum, with the aid, in many caſes, of heat; or ſtrong heat alone.

BALSAMS are natural compounds of reſins, and eſſential oils, combined, (in a manner different, nevertheleſs, from what they can be by art, when once ſeparated,) by the mediation of an acid; which is found to riſe copiouſly on the decompoſition of balſams by heat, in the degree of boiling water. Balſams, afforded by different plants, are very various in their conſiſtence, and other ſenſible qualities, from each other: as alſo, with reſpect to the other bodies, with which they will combine. Some are perfectly ſoluble in ſpirit of wine; and others reject that menſtruum, and combine freely with ethereal oils. Many, likewiſe, commenſtruate freely with ſubſtantial oils; and all with water, by the mediation of lixiviate ſalt, or the ſal ſaponarius. Balſams are decompounded by a leſs a leſs heat than will make water boil; and they yield a quantity of acid lymph, with a larger of ethereal oil; the reſiduum being a perfect reſin, like ſome of thoſe found in a native ſtate, except with reſpect to tenacity, in which the reſins obtained from balſams fall ſhort of the others. This kind of reſin, when obtained from turpentine, and ſeveral other balſams, being urged by a greater heat, riſes almoſt wholly in ethereal oil, and acid lymph; as was before obſerved in ſpeaking of native reſins. Being accended by the contact of any body duly heated, balſams conſume in flame, as eſſential oils or reſins; leaving a very inconſiderable portion of earth. Balſams are obtained from the plants which yield them, in the ſame manner as reſins, by a natural exudation, or from divided parts of the plants; and in ſome inſtances they are made to flow from the ligneous or denſer parts of trees, that contain them, by liquefaction, through ſtrong heat.

GUM-RESINS are natural compounds of gums, and reſins: one part of them being ſoluble in water; and the other in ſpirit of wine: as the extract of the Peruvian bark and opium. But it may be doubted, whether theſe ſubſtances may not be in ſeparate veſſels in the plant, and commixt by the means employed for their extraction. As they are formed of gums and reſins, that appear only commixt, or at moſt combined by ſome very weak medium, they may be decompounded, ſo far as reſpects their reſolution into theſe two ſubſtances, by ſolution; to which end either water or vinous ſpirit may be employed. The further analyſis of theſe ſubſtances, when ſeparated, ſtands neceſſarily on the ſame principles as others of the ſame kind; and conſequently requires not to be diſcuſſed here: having been before explicitly treated of.

Gum-reſins are obtained from the parts of the plants, where they abound copiouſly, and the texture of the parts that afford them are tender and ſucculent, by preſſure; as in the poppy, where they ſubſiſt in the form of the lacteous ſap: but in the caſe of harder ſubſtances, ſuch as the Peruvian bark, and root of the jalap, they require the uſe of a diſſolving menſtruum, and generally the mediation of heat likewiſe.

The ANOMALOUS SULPHUREOUS SUBSTANCES of vegetables (that is, ſuch as are not properly reducible to any of the above claſſes) hitherto known, are *camphor*, *flowers of Benjamin*, *the ſaccharine matter*, *wax*, and *the colorific matter* of the ſtamina, and the petals, of the flowers of many plants. The two firſt of which, indeed, partake ſo much of the nature of concreted eſſential oils, that they are by moſt writers deemed ſo. But, beſides their retaining their ſolid form, when ſublimed with heat, in which they wholly diſagree with eſſential oils, each of them have peculiar qualities, which give properly a diſtinct character to them from ſuch oils. They have an equally great generical difference, in common, from reſins, as from eſſential oils; which is, their riſing, through the means of heat, in their whole ſubſtance, without any analyſis, or decompoſition: and each have, likewiſe, other properties peculiar to itſelf, that are not to be found in reſins.

CAMPHOR is a ſulphureous ſubſtance ſo volatile, that it exhales intirely away, when expoſed to the air, with the common heat of the atmoſphere: and it is not even to be abſolutely prevented from waſting in cloſe veſſels, unleſs ſecured by the moſt effectual means. On being accended, by the leaſt touch of any body luminouſly hot, it flames with great vigour: and is quickly conſumed. It diſſolves, with great readineſs, in ſpirit of wine; and alſo in both ſubſtantial, and ethereal, oils: and, in a manner peculiar to itſelf, in concentrated acids; particularly ſpirit of nitre: combining with ſuch acids in a perfectly thin, and limpid fluid; contrary to the nature of moſt, if not all, other ſulphureous bodies, that will commenſtruate with them: all ſuch others burning them black; and thickening their conſiſtence. It refuſes all combination with water, even with the mediation of any alkaline ſalts: in which it varies eſſentially from other ſulphureous bodies. Camphor is of two kinds: which differ in certain particulars (which we ſhall obſerve more particularly below): but they both agree in the properties above enumerated. The one is brought hither from China, and is obtained by diſtillation from the wood of a tree, which affords an eſſential oil, in which the camphor concretes: the other is found, in a native ſtate, in the iſland of Sumatra, in cavities in the wood of the tree. That brought from China, and produced as is ſaid moſtly in Japan, is the only kind in uſe here; and, being ſent in a crude ſtate, is purified by ſublimation with a gentle heat.

FLOWERS OF BENJAMIN are a vegetable ſulphureous ſubſtance, which is leſs volatile than camphor: but more ſo, than moſt, if not any, eſſential oils. It diſſolves in ſpirit of wine; and alſo in water, when of a boiling heat: though it is not retained by the water, when cold, but ſhoots at the bottom of the veſſel in a chryſtalline needle-like form. In this ſolubility in water, it differs generically from either eſſential oils or reſins; which refuſe all ſuch combination, without the mediation of ſome other body: as it does, alſo, from eſſential oils, in ſubliming in a ſolid form, and riſing without being any way analyſed or decompounded.

It is not be decompounded by heat on the principle of incaleſcence; as may be inferred from its property of riſing in an intire ſtate, with a gentle degree of heat: and when ſubjected to heat, on the principle of combuſtion, it is moſtly diſſipated, like eſſential oils, in flaming. Other means of analyzing or decompounding it, are not hitherto known. Flowers of Benjamin are obtained, by means of ſublimation or ſolution, from the reſin ſo called: and, if by ſublimation, they are in a ſemi-tranſparent flaky form: but, by ſolution, in a chryſtalline needle-like form, as before mentioned.

The SACCHARINE MATTER muſt neceſſarily be enumerated among the anomalous ſulphureous ſubſtances of vegetables; becauſe it has the true characteriſtic property of them, viz. the burning away, when heated, with the acceſs of air, without leaving any, or only a very ſmall quantity of aſhes. But, as the other qualities of this extraordinary body have been examined, in treating of it as one of the ſaline ſubſtances of vegetables, of which claſs it has likewiſe the true character, it is needleſs to dwell further on its nature here.

WAX may properly be deemed to be of a middle nature betwixt reſins, and ſubſtantial oils, as will be found by the experiments, which regard either its decompoſition or combination with other bodies; and its general nature will, therefore, be explained, in common with that of reſins and oils, in the particular conſideration of them below given. It ſubſiſts in plants, in its native ſtate, in a ſolid form, in the three known manners above mentioned; that is, in the farina fæcundans of many ſpecies, which ſeems to be conſtituted only of it, and the ſeminal rudiment of the plant, and is collected by the bees, who form of it their comb, or repoſitories of their honey, and the nidus of their young;—in an extremely thin incruſtation on the leaves;—and in a collected ſtate, in certain trees in North America, called the candleberry myrtle: which laſt kind of wax does not ſeem to differ from the other of the farina fæcundans, in any other property than that of having a green colour, not to be taken away from it, by any means of art hitherto known: whereas the farina fæcundans is of various colours in its original ſtate, always brown when fabricated by the bees into their honey combs, and eaſily rendered white by bleaching in the ſun and air. Wax, in its original ſtate, is neither ſoluble in water, nor ſpirit of wine: but when it has undergone the action of that degree of heat, which will volatilize it, a change with reſpect to the ſpirit of wine is produced; and they will freely commenſtruate. It combines, however, in all ſtates, with ſubſtantial oils, by the aid of heat; and forms, with them, an unctuous maſs. Wax being decompounded by heat, on the principle of incaleſcence, the far greater part of it riſes in an unctuous or oily body of the conſiſtence of butter, together with ſome lymph ſlightly acid and diſguſtfully fœtid: there being little or no recrement or fixt part left behind. The butter, by repeated diſtillations, becomes more fluid. Being urged with burning heat in the open air, the crude wax, as well as the butter diſtilled from it, riſe in flame, till nearly the whole ſubſtance be conſumed: as is well known by the common uſe of it for candles.

The COLORIFIC MATTER of the petals, and flowers, of plants, in many inſtances, appears, likewiſe, an heteroclite ſulphureous ſubſtance: being ſoluble in both ſpirit of wine, water, and oil; in which quality it differs ſpecifically from both gums, reſins, and balſams; as it does, alſo, from wax in diſſolving in the two firſt of thoſe menſtrua. This ſubſtance is in a copious manner, afforded in the ſtamina of the crocus, called ſaffron, where it yields a tincture, by the diſſolving power of any of thoſe menſtrua; the whole appearing to combine with them. This kind of heteroclite ſulphureous vegetable ſubſtance is ſo fixt, that it is not to be raiſed by heat without decompoſition; and, when it is decompounded by heat, it affords the ſame bodies as native reſins, deprived of their eſſential oil, or that which will riſe with the heat of boiling water.

Theſe are the ſeveral ſulphureous ſubſtances, naturally ſubſiſting in, or obtainable by art, from the parts of vegetables: in which, taken together with their gums, the moſt material variations of plants lie, with reſpect to the purpoſes to which they are applied. For, beſides, that theſe ſubſtances conſtitute the tinging matter of plants, the tenacious conſiſtence and ſolubility of ſuch as are ſolid, or capable of becoming ſo, and the diſſolving power of ſuch of them as are fluid, render them of extenſive uſe, as vehicles in painting, varniſhes, printing inks, and in ſeveral other views. Their ſcent, odour, and aromatic flavour, of which qualities they are the repoſitories to the plant, in all parts, except the flower, gives them great value: and they are moreover, either in their native or prepared ſtate, the reſidence, in moſt caſes, of the medicinal virtues of the reſpective plants, whence they are obtained.

The NATIVE ACIDS of plants, which ſhould be carefully diſtinguiſhed from their ſubacid ſalts, are of a peculiar nature: and ought indeed to be enumerated, as a fifth ſpecies in the genus of acids. For though they are generally conſidered, as being the ſame with the acetous acid; yet, on due examination, they evidently appear not to be ſo: their menſtrual attractions, which give the ſtrongeſt mark of diverſity, or ſameneſs in bodies, being greatly different; as are, alſo, the neutral ſalts they form by combination with alkaline ſalts. The native acids of plants vary, however, much from each other: but whether from a difference in their own nature, or from a change by combinations with other bodies, which are produced, together with them, in the juices of the plants, is not eaſily determined; as they do not admit of ſuch decompoſition, as may give due light into it. They have the general qualities of acids, in common with the other ſpecies: but there is hitherto very little further known concerning them, except, that ſome of them are more general diſſolvents of alkaline ſalts, earths, and metals, than any other kind of acid: which is more eſpecially true of the juice of lemons; that cannot be reſiſted even by vitrified borax. There is indeed a principal, and almoſt inſurmountable, impediment to their examination by means of heat: which is, that they never ſubſiſt in the lymph of the plant, without the commixture of other ſucculent bodies of the vegetables; particularly the ſaccharine matter: and when, therefore, an attempt is made to decompound them by heat, the heterogeneous ſubſtances mixed with them are decompounded alſo; and, conſequently, the diſſolved parts of both, riſing together, form ſuch new combinations, as diſguiſe and confound the elements of the acid. But they are nevertheleſs very worthy of examination in ſeveral other views: as they ſeem to have been hitherto neglected. They are moſtly to be obtained from the fruits of vegetables, by expreſſion of the juice, and may be purified from ſolid feculencies, by filtration through flannel or paper; and alſo afterwards concentrated by boiling.

Vegetable ſubſtances are, therefore, the ſubject of experimental chemiſtry, with reſpect to their ultimate decompoſition, by heat and putrefaction;—with reſpect to their ſeparation from each other;—with reſpect to their combination with each other, or with bodies of a different kind;—and with reſpect to the changes that may be produced, without addition or decompoſition, in their colour, conſiſtence, or other qualities. The firſt is to be performed, when on the principle of incaleſcence, by diſtillation in cloſe veſſels: and when on that of combuſtion, by incineration, or deflamation on a proper hearth, or other fit veſſel. The others are too diffuſively various, in conſequence of the multiplicity of ſubjects, widely differing in the treatment required, to admit of being reduced to any general rules: and can only be taught, in the particular experiments reſpecting each kind. It is, however, neceſſary to conſider well the particular nature of any part of a vegetable, which is made the ſubject of experiment, before any concluſion be drawn from the reſult of ſuch experiment, reſpecting the general nature, either of all vegetable ſubſtances, or of thoſe which form particular parts: for there is ſo great a variation in the ſame parts of different plants from each other, and even of the ſame parts, of the ſame plant, in different ſeaſons and climates, that the ſtricteſt care muſt be taken, in deciding any point by the experiments made on one particular ſubject. Thus, for example, the wood of guaiacum, and other kinds produced in hot countries, yield great quantities of oil, on their decompoſition by heat, and no alkaline ſalt; contrarily to the nature of moſt other kinds of plants; which afford lixiviate ſalts, though in much leſs proportion in hot climates than in cold: and, as I am informed on very good authority, leſs in America, even in the ſame latitudes, than in Europe. The ſolid parts of other plants, abounding in eſſential oil, as fennel or cummin, or affording a pungent ſcent, and acrid taſte, as muſtard, or onions, afford a volatile alkaline ſalt on their decompoſition by heat: ſo that any general inference, relative to the bodies produced on the decompoſition of the parts of plants, drawn from experiments made on any one of theſe kinds, would be erroneous and falſe: and the ſame will hold good, with reſpect to many other ſubjects, in a parallel manner to this.

CHAP. II.

Experiments and particular obſervations on vegetable ſubſtances.

SECTION I.

Experiments and obſervations on the ſolid parts of vegetables.

EXPERIMENT I.

Decompoſition of the fibrous or vaſcular parts of plants.

TAKE thin ſhavings of wood; and boil them for two or three hours in water. Then pour off the water, and put them into a ſolution of the ſal ſaponarius, formed, by adding two parts of water to one of the capital lye of the ſope-makers: and let them boil an hour or two more: after which, waſh, and preſs them, well in ſeveral ſucceſſive quantities of water, to free them thoroughly from the ſalts of the lye. Let them be then dried; and afterwards being put into a luted retort; and ſubjected to a ſtrong heat in the naked fire, an acid lymph and an ethereal oil will be raiſed: which oil will riſe at firſt thinner, and afterwards gradually thicker, till it become of a tar-like conſiſtence. The recrement in the retort will be a black coal: which, being burnt on a proper hearth to white aſhes, will be found reduced to perfect, pure earth, of the ſame kind with that afforded by the incineration of animal ſubſtances; or what I have called the organical earth. On adding water to theſe aſhes, they will be found devoid of lixiviate or any other ſaline matter.

OBSERVATION.

Inſtead of ſhavings of wood, paper, or the tendereſt parts of any plants, may be uſed: provided they be previouſly well beat; that the water and lye may more eaſily penetrate into the whole ſubſtance.

The intention of boiling firſt in water, and then in the lye, is to free the fibrous, or proper ſolid part of the vegetable, from all the ſucculent parts: whether in a fluid, or concreted ſtate. The water diſſolving, and conſequently ſeparating, all the ſaline and gummous parts; and the lye, the oleaginous, balſamic, reſinous, or other ſulphureous parts. Without this be done, the parts of plants, affording lixiviate ſalts on their incineration, cannot be made to yield aſhes wholly devoid of them: though Boherhaave aſſerts, that, by boiling in twenty ſucceſſive quantities of water, he brought the wood of roſemary to this ſtate. But whoever will take the extreme great pains, neceſſary to make this experiment, will yet find, they will fail in meeting with this reſult; ſince, whether it be that the reſinous parts of the plant furniſh, together with the earth, the proper elements of lixiviate ſalts; or whether the rudiments of them, being in a ſaline ſtate, are defended in the interior parts of the matter, by the gluten of the plants, which is of a reſinous nature; it appears, that without the uſe of ſuch a menſtruum as will diſſolve reſinous bodies, lixiviate ſalts will ſtill be produced on the incineration. For in the manufacture of paper, the contuſion, and maceration, are fully ſufficient to bring out all that water can diſſolve; and yet the paper is found to afford ſalts on its incineration. It appears by this experiment, that the proper ſolid parts of plants, wholly diveſted of thoſe that, according to the general obſervations above given, may be deemed ſucculent, are compounded of the organical earth, phlogiſton, oil, the vegetable acid, and water, combined in ſuch a manner, as does not produce lixiviate ſalts, on their decompoſition, through heat, on the principle of combuſtion; nor volatile ſalts, on the principle of incaleſcence: the phlogiſton, acid, and water, being joined to the earth only in ſuch proportion, as is requiſite in order to their ſerving as a gluten to it. The lixiviate ſalt, and alſo the volatile ſalt, which are not actually generated in the combuſtion, are, therefore, either formed wholly of elements furniſhed by the ſucculent ſubſtances: or, if any part of the fibrous ſubſtance do ever enter into their compoſition, it is in combination with ſome of the elements of the ſucculent: as this experiment ſhews, by the fact itſelf, that the fibrous parts, wholly diveſted of the ſucculent, are not capable of producing them: nor, indeed, in many kinds, are even both the ſucculent and fibrous together, as will be more explicitly ſhewn elſewhere.

This proceſs has never been practiſed in the whole, at leaſt in this quarter of the world, but for experimental purpoſes; though the firſt part of it is performed indeed to a certain degree, in the preparation of vegetable matter for the making paper: contuſion by heavy hammers being ſubſtituted, for coction, to divide and break the texture of the fibres, and aid the water in diſſolving and waſhing out all other matter. But I have been informed, that in China, where paper is made of ſome kinds of cane, and other coarſer ſubſtances than flax or hemp; that not only coction is uſed, in the preparation, but even the diſſolving power of alkaline ſalts, to free the fibrous part from the reſinous, or other concreted ſucculent ſubſtances: which would, otherwiſe, render the bodies of too obdurate, and firm a texture, to admit of their fabrication into paper.

SECTION II.

Experiments and obſervations on the ſap of vegetables.

EXPERIMENT I.

Collection of the aqueous ſap of vegetables.

IN order to obtain the aqueous ſap from living trees, let punctures be made in the ſpring or autumn into the ſtem; and, if practicable, on the outward ſide of ſome curving part; ſo that the orifice may be depending;—or where that is not convenient, the puncture being made, let a ſmall pipe, formed of a quill, be joined to the orifice, by putting it juſt within the hole, and fixing it obliquely downwards, by means of ſome pitch; or, which is better, melted reſin: taking care, nevertheleſs, that the cavity be not choked up in doing it. Let a proper veſſel be then placed, under the orifice or pipe, and the ſap will be diſcharged into it, in various quantities, according to the nature of trees, and the effect of the ſeaſon.

In the minuter and green parts of plants, where their texture admits of it, the aqueous ſap muſt be obtained by expreſſion: which may be performed, by firſt bruiſing the parts of the plants, by pounding them in a wooden or glaſs mortar; and then putting them, in a linnen bag, into a ſcrew preſs; or betwixt two boards, with a large weight laid on the upper, placing a proper veſſel to catch the ſap as it flows from the preſs or boards. In ſome particular inſtances, the parts of plants being cut aſunder, and laid in a due poſition, will bleed conſiderably; as is found in the aloe. In which caſe, the ſap ſo obtained, is to be preferred to that procured by expreſſion.

OBSERVATION.

The aqueous ſap is not to be obtained, by bleeding, from all trees that contain ſuch: as it either does not abound in ſufficient quantity, or does not circulate with ſufficient vigour, to flow from the wounds: and in ſuch caſes, it is beſt extracted, from the leaves or tenderer branches, by expreſſion, as here directed. The ſame method is, likewiſe, the moſt proper for obtaining the ſap from herbaceous plants: but it is not, however, certain, in all caſes, that the fluid, thus obtained by expreſſion, is the ſap alone; and not a mixture of that, and ſome ſecreted juices peculiar only to certain parts.

The method of collecting the aqueous ſap, by bleeding the trees, is practiſed in our own country, on the birch-tree; in order to the making wine of the juice obtained; and in America, on the ſugar maple, for extracting ſugar; and, in other places, for procuring other uſeful ſubſtances: and, if the nature of many trees, yet unexamined, in this light, were to be properly explored; doubtleſs, conſiderable advantages might be derived from it. The method of obtaining the aqueous ſap, by expreſſion, is alſo in frequent uſe, for various purpoſes: but that of procuring it from the divided parts of plants, by bleeding, is only practiſed, that I know of, in order to the extraction of the gum of the aloes.

EXPERIMENT II.

Decompoſition of the aqueous ſap of vegetables.

Let the ſap be firſt treated, as is directed in Experiment VI. Sect. IV. Part. II. Vol. I:

and, if it appear, after due evaporation, not to be tenacious or viſcid, place it as there directed, to ſhoot its eſſential ſalts: but if it be found glutinous, or mucilaginous, reduce it to dryneſs in balneo mariæ. The ſame may be done, alſo, with the fluid remaining after the eſſential ſalts are obtained.

OBSERVATION.

By this means, the ſalts, or gummous ſubſtances, which, together with lymph or water, and the vegetable acid in ſome caſes, conſtitute the whole of the aqueous ſap of plants, may be ſeparated from each other: and the true nature of the ſucculent œconomy of the plants, whoſe principal blood is of this kind, known: which, by a more ſedulous and extenſive obſervation than has been hitherto made, might lead not only to the diſcovery of ſubſtances uſeful for many purpoſes; but to the explaining many important points, reſpecting the peculiar conſtitution and qualities of the various kinds of plants.

The more particular nature of the ſeveral ſubſtances, obtained by theſe means of decompoſition, will be treated of, under the reſpective heads to which they belong, according to the diſpoſition explained in the general obſervations: which renders, therefore, any further diſcuſſion of it here unneceſſary.

EXPERIMENT III.

Collection of the lacteous ſap of vegetables.

Make punctures, or inciſions, in the plants, which appear to afford a milky juice; and catch the drops of the matter, as it flows from the wounds:—or, as only minute quantities can be obtained by this means, uſe expreſſion, as directed in the preceding experiment.

OBSERVATION.

This kind of ſap is rarely afforded, at leaſt in our country, but by ſmall herbaceous plants; as the thiſtle kind, celandine, or poppies: and, therefore, where larger quantities are required, it muſt be procured by expreſſion.

The obtaining the lacteous ſap of plants, by bleeding them, is not practiſed in our country, unleſs for experiment: but the collecting it by expreſſion, after a previous coction in water, is in conſtant uſe, for the preparation of the diacodium or ſyrup of poppies; and on other occaſions.

EXPERIMENT IV.

Decompoſition of the lacteous ſap of plants.

Evaporate the lacteous ſap, firſt, over the fire, till it be as far inſpiſſated as may be without hazard of burning it to the veſſel; and then bring the remaining matter to abſolute dryneſs in balneo mariæ. Take then the dry ſubſtance, thus obtained; and, having reduced it to powder, add to it ſtrong ſpirit of wine; and, putting it into a proper circulating glaſs, ſet it to digeſt in a moderate heat: where let it ſtand a day or two, ſometimes ſhaking the veſſel. If the ſpirit of wine appear then, to have diſſolved a part of the matter, pour off the clear ſolution, and again evaporate it to dryneſs: and having ſtrained off the ſolution from the undiſſolved part, waſh it in ſeveral ſucceſſive quantities of ſpirit of wine, and then dry that alſo. By this means, if the ſap contained both a gummous and reſinous ſubſtance, as is moſtly the caſe, with reſpect to this kind, they will be perfectly ſeparated: that recovered from the ſpirit of wine being reſinous, and that left by it, gummous.

OBSERVATION.

The reaſon of the uſe of ſpirit of wine, in this experiment, is becauſe the extract from the lacteous ſap is for the moſt part a gum-reſin:

which being, as we ſhall have occaſion to obſerve more diſtinctly below, compounded of a gummous, and reſinous body, admits, therefore, of a ſeparation of thoſe conſtituents from each other. But, in ſome inſtances, nevertheleſs, that, which gives the milky body to the ſap, is a reſin alone, combined with the water by ſome medium that is always deſtroyed, in conſequence of its firſt ſeparation from it: and never admits of being combined with it, without the ſuperaddition of ſome other body; but is ſoluble, nevertheleſs, in its whole ſubſtance, in ſpirit of wine.

The proceſs is practiſed, with reſpect to the firſt part, or ſeparation of the ſolid matter of the lacteous ſap from the water, for the extraction of opium from poppies; and many other gum-reſins and reſins, from the plants which afford them: and, with reſpect to the ſecond part, for the ſeparation of the gummous, and reſinous, ſubſtances, contained in gum-reſins, for medicinal uſes.

EXPERIMENT V.

Collection of the ſulphureous ſap of vegetables.

Proceed as with the aqueous ſap in Experiment II: in that part, which regards the obtaining it, by bleeding the trees.

OBSERVATION.

There is not, as far as I am informed, any tree, or plant indigenous in our country, which affords this kind of ſap only: but it may be found alone in ſome ſpecies of the toxicodendron, an American exotic, that will live here even in the open air. The ſap is not, however, to be collected here from theſe trees in any quantity, though there is very good authority for believing, that, in China, and Japan, the common black varniſh, which we ſee ſo frequently under the name of the Japan laquer, is no other than the ſulphureous ſap of a ſpecies of this kind of tree: but it is moſt probable, we have not the true ſpecies; and that, moreover, if we had, it would not thrive ſo well in our climate, as to produce its ſap in full vigour. But we have not the leaſt reaſon to regret the want of theſe trees, however uſeful they might be in commerce; ſince their deleterious qualities render them fatally pernicious to thoſe who are concerned with them: as not only appears, from the accidents that have happened in America, where there are ſeveral ſpecies of them, to thoſe who have incautiouſly burnt, or handled the wood; but from the effects of the varniſh itſelf, formed of the ſap that has been brought hither. For this varniſh has been extremely noxious to all the workmen, who have had any concern with it: inſomuch, that, notwithſtanding very conſiderable benefits would ariſe to ſome manufacturers from its uſe, they are obliged to deſiſt from it, on account of the want of workmen who are willing to undertake, even at any rate, to apply it.

SECTION III.

Experiments on the ſaline parts of vegetables.

EXPERIMENT I.

Extraction of the eſſential ſalts of vegetables.

See Experiment VI. Sect. IV. Part II. Vol. I.

EXPERIMENT II.

Decompoſition of the eſſential ſalts of vegetables.

TAKE eſſential ſalts; and, having put them into a retort, diſtil them, as is before directed, Experiment IV. Sect. IV. Part II. Vol. I. for tartar. Oil, and acid lymph, will be raiſed, in the ſame manner as from tartar; a coaly ſubſtance being left behind: to which water being added, it will yield a conſiderable quantity of lixiviate ſalt, but in an impure ſtate: a part of the fixt, though burnt, oil being combined with the water, in the ſolution, by means of it.

EXPERIMENT III.

Decompoſition of eſſential ſalts on the principle of combuſtion.

Take eſſential ſalts; and treat them as before directed in Experiment V. Sect. IV. Part II. Vol. I. for tartar: and the reſult will be the ſame.

EXPERIMENT IV.

Formation of tartar. See Experiment III. Sect. IV. Part. II. Vol. I.

EXPERIMENT V.

Decompoſition of tartar by incaleſcence.

Treat the tartar according to the directions in Experiment IV. Sect. IV. Part II. Vol. I. and, after the diſtillation, take the coal out of the retort; and add boiling water to it; bruiſing it in the water, that it be thoroughly mixt with it. The water will then diſſolve a ſaline body contained in the coal; and alſo, by the mediation of the ſalt, a part of the ſulphureous matter of the coal. Filter then the ſolution; and evaporating it to dryneſs, the ſaline body will be found to be lixiviate ſalt, abounding in a conſiderable quantity, but impure, with the ſulphureous matter diſſolved along with it, out of the coal: from which, nevertheleſs, it may be eaſily freed, by ſubſequent calcination.

OBSERVATION.

The lixiviate ſalt found (as in this experiment,) in tartar, and alſo in eſſential ſalts, on their decompoſition by heat without combuſtion, gives occaſion to doubt, (as was before obſerved,) whether lixiviate ſalt be generated in the vegetable in its natural ſtate; or produced, in the decompoſition of the proper parts, by heat. For, in all inſtances, except in the caſe of tartar and eſſential ſalts, combuſtion is neceſſary to the production of lixiviate ſalt; and conſequently, being yielded by theſe ſalts through incaleſcence only, it appears, that the elements which form it, are in a different ſtate in them, from what they are in the others; and neceſſarily ſuggeſts, that it is probable it was pre-exiſtent in them, to the decompoſition; and only freed in that change from the acid, which may neutralize it; and from the oil that is, alſo, combined with it. An objection might be brought, againſt this ſuppoſition, from its lixiviate ſalt's never being found in the parts of any plant in its own proper alkaline nature: but this may be obviated by the conſideration, that acid

apparently

apparently abounding in the ſame parts of the plants, where it is formed, it may be neutralized, as ſoon as generated; as the volatile ſalt obviouſly is, in the blood of animals, where it is never found, but in a neutralized ſtate, or the form of Ammoniacal ſalts. This point regarding the production of lixiviate ſalt is not, however, yet determinable from any argument, or experiment already known; but all other appearance, except this production of it from tartar, and eſſential ſalts, ſeem to indicate that combuſtion is neceſſary to their generation.

EXPERIMENT VI.

Extraction of the ſaccharine matter from vegetables.

Take the parts of vegetables, which are of a tender kind; and having bruiſed them, pour boiling water on them; and, after they have infuſed for ſome time, ſtrain off the fluid, in which the ſaccharine matter will be diſſolved, through linnen, uſing moderate preſſure. Evaporate then the ſolution, till the matter appear thick; and then dry it in balneo mariæ. In the caſe, however, of fruits, and of the very ſucculent parts of plants, the uſe of water is omitted; and preſſure alone is uſed; which muſt be greater, or leſs, according to the texture of the ſubject, and the abundance or property of the juice. Where the ſaccharine matter is contained in ſeeds, as in the caſe of corn or pulſe, the body of them muſt be opened, before it be obtained: in order to which they muſt be firſt well ſoaked in hot water; and then laid in heaps, of conſiderable bigneſs, till they begin to ſprout: when they muſt be ſpread on a proper floor, in a place made hot, till they be dry. After this, water of the mean degree of heat, betwixt that of the atmoſphere and what would make it boil, muſt be put on them; and ſtirred about for ſome time: and, when it has ſtood four or five hours, it muſt be drawn or poured off: and if the ſaccharine matter, by this means extracted, be deſired in a dry form, evaporation muſt be uſed.

The juice of grapes, or other fruit containing the ſaccharine matter, and conſequently proper for fermentation, is called *muſt*; and the ſolution made of it, as above from malt, is called *wort*.

OBSERVATION.

The ſugar commonly in uſe, is the native production of the ſugar cane; and requires only to be purified; and there is not at preſent any other prepared for commercial purpoſes: though endeavours have been uſed in ſome of our colonies to obtain it from a kind of maple, called, on that account, the ſugar maple; the ſap of which abounds with it. Attempts have been, alſo, ſaid to have been made, by the French in Canada, to obtain it from the ſarracena: in the folded leaves of which, a ſtrong ſolution is found, in a very extraordinary quantity: but none of theſe have yet been brought to the ſtate of an eſtabliſhed manufacture. There are ſeveral other plants, that afford the ſaccharine matter from different parts: ſome on their leaves, in a concreted form, as that ſpecies called manna; others from their flowers: as one of the large kind of American aloes; from whence it drops, in a fluid ſtate, like a ſhower of rain, in a ſurprizing quantity.

Neither of the methods, directed in this experiment, are, therefore, practiſed in common for the obtaining ſugar, or the ſaccharine matter, in a pure and dry ſtate: but both are practiſed with a view to the production of wine, or vinous liquors, from the ſaccharine matter obtained from the plants, in a diſſolved ſtate: as it is this matter alone, which is capable of that fermentation, which generates vinous ſpirits.

That part of the proceſs, which reſpects the preparation of corn or pulſe, for yielding the ſaccharine matter it contains, is conſtantly practiſed in our country on barley: which is then called *malt*: and the ſolution is, likewiſe, with equal frequency, made in the manner here directed: which is called *brewing*. The neceſſity of this preparation of corn, particularly the harder kinds of grain, for the extracting from it the ſaccharine matter it contains, is in order to open the body of the ſeed, in ſuch manner, that the water may pervade the whole; and combine with the ſaccharine matter: which is, otherwiſe, ſo locked up by, and united with, the other parts of it, that the diſſolving power of the water is in a great meaſure eluded. This difficulty is, therefore, ſurmounted by the ſprouting of the corn: the rudiment of the plant, in its efforts to expand, looſening the texture of the whole body of the ſeed in ſuch manner, that it becomes capable of imbibing aqueous moiſture; and, conſequently, of ſuffering the ſolution of the ſaccharine matter by it to take place. The reaſon of the uſe of water, for making the ſolution, in a mean degree of heat, rather than cold or boiling hot, is founded on the ſame principle: for it is, in order that the water, by its relaxing quality in this ſtate, may penetrate, and inſinuate itſelf, in the moſt intimate manner, into the body of the ſprouted ſeed: boiling water, on the contrary, concreting the gluten, and hardening the ſubſtance of it; ſo as to render it leſs pervious to the moiſture: and cold water in ſome degree effecting the ſame; and, moreover, wanting the ſtronger diſſolving power of the hot.

EXPERIMENT VII.

Decompoſition of the ſaccharine matter by fermentation.

Take ſugar, honey, or any other ſaccharine matter; and diſſolve it in ſix or eight times its weight of water;—or take muſt, or wort, as obtained in the preceding experiment;—and mix with ſuch ſolution, muſt, or wort, by beating them together, a ſmall quantity, in proportion to the whole when mixt, of yeaſt, or the frothy ſcum, which may be taken off other liquor while fermenting. Put the mixture, then, in a caſk or proper veſſel, of which it muſt not fill above two thirds; covering the bung hole with a linnen cloth; and place the caſk or veſſel in a ſituation, where it may be kept of the warmth of the atmoſphere in a ſummer's day. In a ſhort time, an effervеſcence will begin to appear; and form a cruſt of yeaſt on the ſurface; which will continue ſometimes to ſwell, and at other times to fall down to the bottom, always emitting bubbles of air, for ſome days; but variably, according to the ſeaſon, or other attendant circumſtances, till at length it ſettle intirely to the bottom, leaving the ſupernatant liquor clear.

This liquor, thus produced by fermentation, is called *ale* or *beer*, when made from the wort of *malt*; and *wine*, if formed from the muſt of grapes or other fruit; and the ſediment or ſubſided cruſt is called the *mother* or *lees* of the wine. If this fermented liquor be put into a proper alembic, and diſtilled, it will be found to afford vinous ſpirit, as deſcribed in the general obſervations on the parts of vegetables. The remaining fluid, after the ſpirit is raiſed, being water with a conſiderable proportion of acid; and alſo of ſaline matter, of the nature of tartar: as will be found on the decompounding it by means of heat, after it is recovered from the water by evaporation.

The lees being decompounded by heat, in cloſe veſſels, afford an acid lymph, and thick oil: a conſiderable quantity of ſoft coal being left behind; and, if ſubjected to heat with the circumſtances proper for combuſtion, the aſhes will be found to contain ſome alkaline ſalt; but in a much leſs proportion than tartar.

If any fermented liquor, together with its lees, be put into a caſk, or other proper veſſel, bigger than will contain it; the bung-hole being cloſed, ſo that only a ſmall aperture may be left; and the caſk be then placed in a warm ſituation; a ſecond fermentation will ariſe; and the liquor will be decompounded. In this decompoſition, the vinous ſpirit will gradually be deſtroyed; and inſtead of it, will be produced, a peculiar ſpecies of acid, combined with a portion of oil, and the lymph of the liquor: and alſo an oleaginous matter, of a particular kind, which, ſubſiding, will concrete into a ſubſtance of a conſiſtence betwixt that of unctuous and gelatinous bodies.

The ſupernatant acid liquor is called *vinegar:* which being again decompounded through heat, by diſtillation in a retort, yields, with the degree that will make water boil, a purer kind of vinegar; in which, nevertheleſs, a conſiderable quantity of oil reſides, beſides the acid and water; as may be diſcovered by fixing it, through the means of combination, with alkaline ſalts; and then ſubjecting it in cloſe veſſels to the heat that will decompound ſubſtantial oil. For then the maſs will be found to be converted to a black colour; and on ſolution in water the coaly ſubſtance will be ſeparated from the ſalt. The reſiduum of the vinegar, after the more volatile part, that will riſe by this degree of heat, is brought over, will, when urged by a greater heat, afford a ſtronger kind; much more acid, and heavier; but impure in ſcent, and taſte, with a burnt oil. In the retort, after the whole is brought over that will riſe without extreme heat, will be found a coaly matter: which, being ſubjected to combuſtive heat, in the open air, will flame brightly; and at length leave aſhes, formed of earth, and a large proportion of lixiviate ſalt.

The oily concreted matter ſeparated in the acetous fermentation, being decompounded by heat, affords, firſt, a conſiderable quantity of acid lymph; and, afterwards,

terwards, the ſame produce as other oleaginous bodies.

There is, alſo, another partial decompoſition, that wine frequently ſuffers; which is, the ſeparation of its tartarous ſalts, that are ſpontaneouſly departed from it. But to produce this effect, no other means are neceſſary, but to ſuffer it to ſtand at reſt, for a long time, in the ſame veſſel. The tartar is, likewiſe, again decompoundable, being treated as in Experiments IV. and V. Sect. IV. Part II. Vol. I. into oil, water, acid lymph, lixiviate ſalt, and earth.

OBSERVATION.

It is not abſolutely neceſſary, in order to the raiſing and perfecting the vinous fermentation, in muſt, wort, or any other ſolution of the ſaccharine matter, that yeaſt ſhould be uſed: for, without the uſe of any ſuch fermenting medium, if the liquor be kept in a due ſtate of heat, it will be effected: but for the more certain ſucceſs, and expeditious procedure, it is beſt to uſe it, even in experiments. There, is, however, another method, where yeaſt is wanting, of anſwering the end of it: or indeed of making a kind of original yeaſt or leaven. This method is, the mixing flower or meal, and water, with ſome ſmall proportion of ſugar, honey, or any other ſaccharine matter, in a moiſt paſte; and letting it ſtand, in a moderate degree of warmth: by which treatment, in a day or two, it will ſwell and ſhew evident ſigns of ſtrong fermentation, at which time, being broken into ſmall pieces, and put into the matter intended to be fermented, it will ſoon communicate that ſtate to it, in as certain, though ſomewhat leſs ſlow, manner, as yeaſt.

The more particular management of fermented liquors, in order to the ſeparation of the vinous ſpirit from the water, and other ſubſtances, with the nature and decompoſition of the ſpirit itſelf, will neceſſarily occur, in its proper place, in treating of the ſpirit itſelf: and it is, therefore, properly omitted here: as is, alſo, the decompoſition of tartar before given.

In the acetous fermentation, as well as the vinous, a fermenting medium may be uſed for expedition, to excite the firſt action of the commenſtruating bodies on each other; and raiſe the effervescence more quietly. But in this caſe, inſtead of yeaſt, the footſtalks of grapes, or the tender branches of vines, may be uſed, being firſt ſoaked in vinegar: or, when to be ſo procured, taken out of vinegar, after having lain there during the fermentation which produced it. For theſe, being freed from the gelatinous or fecal matter adhering to them, and ſlightly waſhed, will, on being put into the liquor intended to be fermented, quickly produce the effect: as is found in the common manufacture of vinegar. The uſe of ſuch a medium is always practiſed in the large works for making vinegar for ſale: but where this kind of matter is not at hand, ſour wine or beer, or ſour lees of them, will anſwer the end.

The firſt part of this proceſs is conſtantly practiſed on muſt, ſolutions of ſugar, or the ſaccharine matter of raiſins, the expreſſed juices of fruits, or the aqueous ſap of ſome trees, for the production of wine: or on wort, or the ſolution of the ſaccharine matter of corn, for the production of ale or beer, or with the view of extracting the ſpirit; in which caſe it is called *brewing*. The ſeparation of the ſpirit from the fermented liquor, is alſo univerſally practiſed, under the technical name of *diſtilling:* the produce, when from wine, being called *brandy*;—when from the feculencies of ſugar in the extraction from the canes, or in the refinement when practiſed in the Weſt-Indies, *rum*; but in England, *melaſſes ſpirit*, when from the feculencies in the refinement;—when from rice, or ſugar, with the juice of the cocoa-tree, in the Eaſt-Indies, *arrack*;—and when from corn, *malt ſpirits:* but when any of theſe are rectified, by repeated diſtillation, till the peculiar ſcent and flavour, they at firſt poſſeſſed, be taken away, they are called *ſpirit of wine*.

The laſt part of the proceſs is, likewiſe, conſtantly practiſed in the production of vinegar, for the various purpoſes reſpecting diet, and medicine, for which it is uſed. That which is moſtly conſumed in this country, is made of corn: and only differs, when pure, from that made of wine, or other matter capable of fermentation, in retaining ſome ſmall remains of the ſcent and flavour, which the liquor had before its change by the acetous fermentation. For, as the ſaccharine matter, when pure, is the ſame in whatever vegetable produced; ſo the vinegar, formed of it, is always the ſame; excepting ſuch difference, as may ariſe from other ſubſtances mixt with it. It is, however, at preſent too prevailing a practice, to commix a cheap ſpecies of mineral acid with the vinegar made in the large works for ſale, which renders it of a different nature from what is produced by the ſecond fermentation of vegetable ſubſtances: and though this is pretended to be done only with the intention of rendering it clear, or, as it is called, *fining down the vinegar*; yet the large proportion uſed, evidently ſhews, it is employed with a view of increaſing the quantity of acid, without the expence of vegetable materials.

EXPERIMENT VIII.

Decompoſition of the ſaccharine matter by heat.

Take ſugar; and diſtil it in a retort, in a ſand heat: and the greateſt part will riſe in acid phlegm; and ethereal oil, at firſt of a thinner, and afterwards of a thicker conſiſtence: leaving only a ſmall proportion of coaly matter.

Or ſubject it to burning heat, with the acceſs of air, and it will be almoſt wholly diſſipated in flame, and ſmoke; leaving only a ſmall proportion of aſhes.

OBSERVATION.

This experiment ſhews, that ſugar may be juſtly deemed of a ſulphureous, as well as ſaline nature: as the phlogiſton bears ſuch proportion to the earth, and other elements, as renders it combuſtible, in ſuch degree, that the far greateſt part of its conſtituent matter is diſſipated. This, conſidered with its ſaline properties, and that of ſuffering thoſe extraordinary decompoſitions, of which wine, vinegar, vinous ſpirit, ether, and tartar, are produced; and alſo the earth, groſſer oils, and ſalts, that are alſo ſeparated in the production of theſe ſeveral ſubſtances, render the ſaccharine a moſt worthy object of ſpeculation; in reflecting, that a ſubſtance, ſeemingly ſo homogeneous and paſſive, in a dry ſtate, ſhould poſſeſs, both the qualities of a ſalt and ſulphur, which are conjoined in no other known body in a perfect degree; and, at the ſame time, be capable, on being diluted with water, which acts merely as a vehicle to the parts of it, to produce from its own ſpontaneous action, ſo great a variety of other compound and ſimpler bodies; ſome of them of a nature extremely various, with reſpect to themſelves, and to all other kinds. The ſalt, ſaid to be formed by the eſſential oil of cinnamon, on long keeping, is, indeed, an inſtance of a ſulphureous ſalt; if its ſaline qualities be perfect; but as it requires, according to what is ſaid of it, twenty years to its production, it has been ſeldom ſeen in Europe; and nothing that can be depended upon, in that view, has been hitherto related of it by thoſe who have procured it: and it is, therefore, probable, that its ſolubility in water is not perfect; but may be of the ſame kind with that of flowers of Benjamin: which ſubſtance is a ſulphureous body of an imperfectly ſaline nature, diſſolving in water of a boiling heat, but being rejected by it when cold.

This decompoſition of ſugar, by heat, is not practiſed, unleſs for experiment, except in the caſe of that imperfect burning, by which the ſugar is ſometimes prepared here, in order to be employed as a part of the means of counterfeiting, or adulterating, French brandy, by other cheaper kinds of vinous ſpirits.

EXPERIMENT IX.

Recovery of the Ammoniacal ſalts of vegetables, by combuſtion and ſublimation of the ſoot produced.

Take oaken wood; and, having put it under a chimney where the ſoot may be collected, ſet fire to it; ſuffering the air to have acceſs. The ſmoke will be condenſed againſt the chimney in the form of ſoot: of which, when a proper quantity has ſettled, let it be ſwept together;—or, to avoid this trouble, take the ſoot formed by the wood burnt in a baker's oven.—With this ſoot, thoroughly well burnt, and dry, fill a large coated retort, almoſt to the neck; and place it in the open furnace; fitting to it, a proportionable capacious receiver. Diſtil then, with a moderate heat, ſo long as a clear lymph is raiſed: and, when the vapour begins to abate, augment the fire gradually; and a further quantity of lymph will come over of a turbid whiteneſs. The fire being ſtill more increaſed, a yellow volatile ſalt will be copiouſly ſublimed, incruſting the receiver over its whole ſurface. On urging the heat to the moſt intenſe degree, a thick black oil will come over: which ceaſing to riſe, diſcontinue the fire. The veſſels being cold, in the neck of the retort will be found ſome ſalt: and in the body of it, over a maſs of black recrement, a cake of the ſame, moderately thick; reſembling, in colour and texture, the common ſal Ammoniacus; and appearing, on due proof, to be a true Ammoniacal ſalt; but with an acid, different from the mineral kinds.

OBSERVATION.

This experiment evidently proves, that vegetable matters are capable of affording Ammoniacal ſalts on their decompoſition by combuſtion: but whether ſuch Ammoniacal ſalts ſubſiſted in the plants themſelves, while in their natural ſtate, or were generated in the combuſtion, by the combination of volatile ſalts then formed, and acid at the ſame time, ſet looſe from the other ſubſtances, remains a doubt. As it is certain, nevertheleſs, that volatile alkaline ſalts are produced in many plants, and acid in all, it is very reaſonable to believe, they may meet in ſome kinds; and form Ammoniacal ſalts: and the recovery of volatile ſalts copiouſly, by that degree of heat which decompounds all the parts of vegetables, from plants producing ſuch as riſe with the heat of boiling water, gives great reaſon to ſuſpect, that ſuch volatile ſalts, as could only be raiſed by the greater degree of heat, were in an Ammoniacal ſtate in the plant, and decompounded by the action of the burnt oil, which is capable of departing fixt alkaline ſalts from acids with the aid of a certain degree of heat. The quantity alſo of Ammoniacal ſalt, afforded by the ſoot of ſome kind of plants, gives room to believe, that the whole are not generated in the combuſtion: for this quantity will appear very large, in proportion to the other conſtituents of the ſoot, when allowance is made for the volatile ſalt found, according to this experiment, incruſted on the ſurface of the receiver; and diſſolved in the lymph: all which muſt have been in an Ammoniacal ſtate till departed from the neutralizing acid by the burnt oil of the ſoot. For, were ſuch volatile ſalt in the ſoot in its ſimple ſtate, it would riſe with the firſt lymph; and not endure that augmentation of the fire, which is neceſſary to its ſublimation, in this experiment; and which ſhews it to be in a ſtate, where its volatility is controlled: which can be only from its combination with acids: from which acid ſuch a portion of it is freed, in the ſublimation, as comes in contact with that part of the oil in the ſoot, which is in the

ſtate

ſtate proper for departing, with the acid of heat, alkaline ſalts from acids.

Experiments, reſpecting the native ſalts of plants, have not, however, been made with ſufficient diligence and accuracy to determine, in what kinds, or parts, of plants, ſuch as are Ammoniacal, reſide: nor in what proportion, they are produced, in various parts, or kinds, by the combuſtive action of heat: though it is a ſpeculation of an extremely curious nature; and would probably lead to the explanation of ſeveral important points, as well in the animal, as vegetable œconomy.

EXPERIMENT X.

Extraction of the native volatile alkaline ſalts of plants, by the heat under the degree that will make water boil; exemplified in the caſe of muſtard-ſeed.

Take muſtard-ſeed; and put it in a coated retort placed in a ſand heat: luting to it a receiver. Diſtil, with a heat ſomewhat leſs than will make water boil, and the vapour that will riſe will condenſe in a lymphous fluid. Continue the heat of this degree ſo long as any fumes appear to riſe; and then having taken off the receiver,

ceiver, the fluid will be found to be, a ſolution of volatile alkaline ſalt, correſponding, in all its properties, with thoſe produced by the putrefaction, or decompoſition, through heat of animal ſubſtances.

OBSERVATION.

This experiment fully demonſtrates the exiſtence of native volatile alkaline ſalts in vegetables of ſome kinds. For the heat employed here for their ſeparation from the other matter, they are conjoined with in the ſeed, is not ſufficient, either to generate them; or even to ceaſe their departure from acids, by means of exalted oils. It is, however, only particular plants, which afford native volatile alkaline ſalts, by this treatment: but the ſeat of them is extremely various in different kinds; in ſome abounding moſtly, if not ſolely, in the ſeeds; in others in the roots; and in many, though in a leſs proportion than in particular parts, throughout the whole.

This proceſs is not practiſed for any uſeful purpoſe; the quantity of volatile ſalts to be ſo obtained, not anſwering to the trouble, and expence, of procuring them by this means.

EXPERIMENT XI

Extraction of volatile alkaline ſalt from vegetables, by heat, on the principle of incaleſcence, in the degree that will decompound all animal and vegetable ſubſtances.

Take the retort, with its contents, as they remain after the preceding experiment; and, having put it into an open furnace, diſtil with a gradual heat. After ſome diſcoloured lymph, accompanied with ſome volatile ſalt, which will be diſſolved by it as it riſes, a black light oil will come over copiouſly; and, along with it, volatile alkaline ſalt; forming ſpots on the ſides of the receiver. In the bottom of the retort will be found, a light black coaly maſs, formed, as it were, of the ſeeds melted together, from whence, ſome have aſſerted, that, by urging it with a very intenſe fire, they have obtained a volatile phoſphorus, reſembling that of urine. Being incinerated, this coal does not afford any appearances of lixiviate ſalt.

OBSERVATION.

From the production of volatile alkaline ſalt, by this degree of heat without combuſtion, it may be reaſonably preſumed, that ſuch ſalt was really exiſting in the vegetable matter, before it was ſubjected to the heat; though fixt by means of acid combined with it: which acid was afterwards departed by the action of the oil, abounding in the part, and exalted, by the heat, to that ſtate, in which it has the power of departing alkaline ſalt from acids. It is, however, together with the abundance of Ammoniacal ſalt found in ſoot, a ſufficient ground to preſume that there are native Ammoniacal, as well as volatile alkaline ſalts, in vegetables: and to give incitement to the further examination of thoſe vegetable ſubſtances, which appear of ſo peculiar a nature in this point, in order to the clearing up that matter.

This proceſs is not applied to practice in any way: ſince animal ſubſtances, which are to be obtained at a much lower expence, yield, by the ſame treatment, volatile alkaline ſalt, not at all different, when pure, from thoſe obtained from theſe parts of vegetables.

SECTION IV.

Experiments and obſervations on the gummous ſubſtances of vegetables.

EXPERIMENT I.

Extraction of gums from the parts of vegetables, by inciſion, compreſſure, and coction.

WHERE gums are deſired to be obtained from living trees, inciſion ſhould be made in the bark, near the joints of the branches: from whence the gum will, in time, flow, and may be gathered.

Where the gums are to be obtained, from the juice of tenderer and green parts of plants, let ſuch parts be firſt well bruiſed; and then pour on them as much boiling water, as will overflow them in the veſſel containing them: let them infuſe for twelve hours, or more, when the fluid muſt be ſtrained off, through a coarſe linnen bag; and the bag, with the remaining maſs, put in a ſcrew-preſs; and there drained of all that can be forced from it; which muſt be added to the fluid, before obtained, by ſtraining. The whole, ſo obtained, muſt afterwards be evaporated, firſt, in the common way, to a thick conſiſtence; and then to dryneſs, in balneo mariæ.

Where gums are to be extracted, from the more compact and ſolid parts of plants, as ſeeds or wood, let the ſeeds, if large, be groſsly pounded; and the wood be either brought to the ſtate of raſpings or ſhavings: and then let the matter be boiled four or ſix hours in a conſiderable quantity of water, after which, let the decoction be filtered through flannel; and then evaporated to a thick conſiſtence, over a common fire, and reduced at laſt to dryneſs in balneo mariæ.

OBSERVATION.

By ſome one of the above methods, the gums contained in any parts of vegetables may be extracted from them: but thoſe perfect gums, moſt in uſe, which are the Arabic, and Senegal, are native; that is, exuding ſpontaneouſly from the trees, which afford them. A ſimilar kind are yielded by the cherry, and ſome other fruit trees in our own country: but not in ſuch quantities, as to anſwer any commercial end.

The method of extracting gums, by compreſſure, is ſeldom practiſed here, but on the poppies: and there the gum, which is extracted, is not reduced to a dry body, but kept in a diſſolved ſtate, in the form of a ſyrup; ſugar being added to the ſolution for that end.

The method of extraction, by coction, is more frequently uſed, both in the formation of mucilages, for medicinal uſes, and in the preparation of pigments and tinctures, for the purpoſes of painting and dying: particularly with reſpect to the latter, from the ſeeds called the French berries, weld, and other ſuch vegetable ſubſtances, as yield their tinging matter to water.

EXPERIMENT II.

Solution of gums in water.

Powder the gums; and add them gradually to a due proportion of water, which, for the readier diſpatch, ſhould be of a boiling heat, ſtirring the mixture well about, or ſhaking the veſſel which contains it, till the powder appear to be diſſolved.

In the more perfect gums, a tranſparent equal ſolution is obtained: but in others, as the Ammoniacum, a lacteous, or milky ſolution is the reſult. In the gum-tragacanth,

canth, only a yet more imperfect ſolution is effected: for the gum does not, as in others, become one homogeneous ſubſtance; but enlarges its volume by imbibing, as it were, the water, and forming with it a kind of gelatinous body.

The ſolution of all theſe kinds of gums is practiſed on many occaſions, either for medicinal, or other purpoſes: particularly thoſe of the perfect kind, in the inſtances of the Arabic and Senegal, not only for emulſions in medicines, but for callicoe printing, painting, and many other uſes.

EXPERIMENT III.

Solution of gums in ſubſtantial oils; exemplified in gum Arabic.

Take linſeed-oil; and, having heated it in a proper veſſel till it boil, add gum Arabic, powdered gradually; and ſtir the mixture well together. The gum will diſſolve perfectly in the oil; producing no apparent change in it, except the rendering it of a thicker conſiſtence.

OBSERVATION.

This ſolubility of gums in ſubſtantial oils, as well as water, appears extraordinary: but it evinces the affinity of nature betwixt them, and reſins: which ſeem, in fact, to differ in nothing but the commenſtruating with, or rejecting ſpirit of wine or water; and the being conſtituted of a different proportion of oil and earth; as their decompoſition ſhews.

This ſolution is only practiſed in the preparation of ſome varniſhes; and that, but rarely; the reſins generally being uſed inſtead of it on ſuch occaſions.

EXPERIMENT IV.

Decompoſition of gums by heat.

Take gum Arabic; and, having put it into a retort, diſtil in a ſand-bath with a gradual heat. A lymph will riſe at firſt devoid of all ſcent, colour, and flavour; but, afterwards, of a browniſh colour, and acid taſte, accompanied with a reddiſh oil; and, as is aſſerted by ſome, a ſmall proportion of volatile alkaline ſalt. The oil in this, as in moſt other decompounding diſtillations of animal and vegetable ſubſtances, will firſt come over of a thinner; and, afterwards of a thicker conſiſtence: the colour growing deeper, as the ſpiſſitude increaſes. In the retort, will be found a conſiderable quantity of coaly matter; ſuch as is afforded by other vegetable ſubſtances.

If gums be ſubjected to a burning heat, with the acceſs of air, they will flame for ſome time: after which, the coal, remaining, will glow till only white aſhes are left. The aſhes, thus obtained; or from the coal produced in cloſe veſſels, by treating it in the ſame manner; will be found, through the means of ſolution with water, to contain ſome proportion of lixiviate ſalt.

OBSERVATION.

This experiment ſhews the difference betwixt gums, and reſins, to lie in the proportion, and the diverſity of nature, of the oils they contain. The gums containing much leſs than the reſins; and that, which they do contain, not being of an ethereal nature, till rendered ſo by heat: for gums will not burn of themſelves, when accended, as reſins; but require exterior heat to exalt their oils to a combuſtible ſtate. From this circumſtance in their conſtituence, they are capable of producing lixiviate ſalt: which thoſe part of vegetables, that abound in eſſential oils, as reſins, are not; and their ſolubility in water, ſeems owing to the ſame reaſon: as ſuch ſolubility moſt probably depends, in all caſes, on the relative proportion of earth, acid, and phlogiſton: the more combuſtible kinds of bodies refuſing to combine with the water; except the ſubſtances in which a large proportion of acid is found; as in vinous ſpirits.

SECTION V.

Experiments and obſervations on the ſulphureous parts of vegetables.

EXPERIMENT I.

Separation of ſubſtantial oils from the parts of vegetables by expreſſion.

TAKE the parts of vegetables from whence the oil is to be extracted; and, if they be farinous ſeeds, or ſuch bodies as admit of pulveriſation, reduce them to powder, by grinding or pounding: but, if they be of a tougher, and more adheſive nature, bruiſe them, by pounding in a glaſs or wooden mortar, to a paſte-like conſiſtence. After the matter is thus prepared, put it, incloſed in a canvas or coarſe linnen bag, firmly tied up, into a ſcrew-preſs; warming the plates of the preſs by immerſing them in boiling water; and let the oil be expreſſed, out of the matter, by the utmoſt force of the ſcrew.

OBSERVATION.

By this means, the oil may be obtained from thoſe parts of plants that abound in it: which are principally the ſeeds or fruits. But where the quantity to be obtained, is the principal object of regard, the plates muſt be made as hot, as they can bear to be, without burning animal or vegetable ſubſtances; and the matter ſhould be made hot, likewiſe, before it be put into the preſs. On the other hand, where the oil is apt to grow rancid in keeping, or, where it is neceſſary that the flavour and ſcent be preſerved in the utmoſt perfection, no heat ſhould be uſed, either for the plates, or the ſubject matter. There are, nevertheleſs, ſome kinds of ſubſtances, as beans, and other pulſe, &c. that will not yield their oil till they are acted upon by a conſiderable degree of heat; in which caſe, they ſhould be parched in ſome proper iron or copper veſſel, till they be near burning: and then they ſhould be committed to the preſs, while yet hot: the plates being, likewiſe, ſtrongly heated.

Where farinous ſeeds, or ſuch bodies as admit of being powdered, are in queſtion, it will increaſe the produce of the oil, to moiſten the powder, and dry it again before it be put to the preſs, as this treatment opens the texture of the matter, ſo that the oil finds a paſſage more eaſily out of it.

In the caſe of many plants, ſomewhat more than the ſimple ſubſtantial oil is brought out, by the expreſſion, in a combined ſtate with the oil; as is particularly evident in the caſe of muſtard-ſeed: of which, the oil, when not commixt with any other ſubſtance, appears to have only the ſoft inſipid flavour of other fat oils; but, on adding vinegar to it, the hot pungent peculiar taſte of the muſtard-ſeed itſelf is immediately produced in it. This evinces, therefore, that, beſides the ſubſtantial oil, another of the eſſential kind, is obtained from the ſeed by the expreſſion; but being combined moſt probably by means of the volatile alkaline ſalt, abounding, as is ſhewn in Experiment X. Sect. III. in this ſeed, the pungency and acrid effect both of ſuch eſſential oil, and the volatile ſalt, are controlled by the ſubſtantial oil, till vinegar being added, which neutralizes the volatile alkaline ſalt, that was the medium of the combination, the eſſential oil is ſeparated from the ſubſtantial; and its pungency, with the peculiar flavour of the ſeed reſiding in it, again revived. Boerhaave has expreſſed a great degree of admiration, "*cur hoc in oleo preſſo, non adeſt* "*acer odor, acutus ſapor, qui ita excellet in oleis* "*ſtillatitiis? cur acrimonia ſpiritus rectoris qui* "*hoſpitatur in oleo, hic ſe non manifeſtat?*" but had he known that the addition of an acid would revive the acrid odour, pungent flavour, and acrimony of the *ſpiritus rector* (as he terms it) his wonder might have ceaſed; finding that the eſſential oil, in which theſe qualities reſide, was expreſſed, together with a ſubſtantial oil, from the muſtard-ſeed; and that the peculiar qualities were only ſuſpended by menſtrual combination of the matter in which they adhere, as is found in many other inſtances.

This method of ſeparation of oils, is practiſed in our own country on linſeed, to obtain a cheap kind for painting; as this ſubſtance affords the greateſt quantity of any vegetable matter hitherto known: and alſo on rape-ſeed. Attempts have alſo been made here, to obtain an oil from beech maſt, in ſuch manner as might be advantageous for commercial purpoſes: but the project miſcarried. The ſame is alſo practiſed on the kernels of walnuts, and ſeeds of poppies, to procure a tranſparent and colourleſs oil for painting; and on both ſweet and bitter almonds, for the purpoſes of medicine; as likewiſe muſtard-ſeed, as well with a medicinal, as eſculent view. In ſeveral warmer countries, it is conſtantly practiſed on the fruit of the olive-tree, both in a green and mature ſtate: and the oils thence obtained are the principal kinds uſed for eating, burning, the formation of ſope, medicinal applications externally, and many other uſes.

EXPERIMENT II.

Separation of oils from the parts of vegetables, by trituration with water.

Take the matter from whence the oil is to be ſeparated; and, after the parts are firſt groſly broken, reduce it to the conſiſtence of paſte, by pounding it in a glaſs, marble, or wooden, mortar, with the addition of a ſmall quantity of hot water. When the matter is reduced to a paſte-like conſiſtence, again put to it hot water, in a ſomewhat larger proportion, and continue to rub it with the peſtle againſt the ſides and bottom of the mortar, that it may be as much divided, and commixt with the matter, as poſſible. Add then yet more water; and, having ſtirred the mixture well about, pour it into a hair ſieve, to ſeparate the fluid from the remaining ſolid part: to which, being taken out of the ſieve, put freſh hot water; and proceed as before; repeating the ſame treatment ſo long as the water appears to be rendered milky. The fluid, thus obtained, will be of an opake whiteneſs, like milk, the oil, expreſſed out of the body by the trituration, being imperfectly combined with the water by ſome weak medium of a ſaline nature.

This kind of ſolution of oil in water is called *emulſion*: and it may be formed of the matter, from which the utmoſt quantity of oil, that can be obtained by expreſſion, is already ſeparated: for a remarkable proportion will be, nevertheleſs, yet afforded by it, through this treatment.

OBSERVATION.

The cauſe of the combination of the oil and water, in this operation, is not clearly evident: but it may be reaſonably concluded, to be owing to ſome ſaline body, which is weakly combined with the oil; but yet ſo, that in diſſolving in the water, it unites the oil alſo with it. This ſaline body, is moſt probably the ſaccharine matter; which, by the great aceſcence of emulſions, apparently abounds in them: but its operation, in this view, is probably aided by ſome proportion of vegetable acid; which we ſee, in many other inſtances, nature employs as a medium in combining oils and water, though it has a contrary effect, when any commixture is made of theſe bodies by means of art.

This method of the ſeparation of the oil from kernels of nucleous fruit, is practiſed for medicinal purpoſes; but generally on almonds only; that are previouſly to be blanched; or, in other words, to have their ſkins peeled off; which is effected by dipping them in hot water.

EXPERIMENT III.

Separation of vegetable ſubſtantial oils, from the parts of vegetables, by coction.

Take the parts of vegetables, from whence the oil is to be ſeparated; and, having prepared them, as is directed in Experiment I. put them into a proper pan with water; and boil them a conſiderable time. When the fluid is again grown cold, the greateſt part of the oil will ſwim on the ſurface; from whence it may be ſkimmed off, and afterwards freed from any water, remaining with it, by means of a tritorium, or ſeparating funnel.

The matter, out of which the oil has been preſt, as in Experiment I. may, by this treatment, be made to afford an additional quantity.

OBSERVATION.

The practice of collecting oil from the parts of vegetables by boiling, has hitherto been very little perſued: the method of expreſſion being much leſs troubleſome and tedious; and the oil obtained more clear and fluid. But, as the ſeparation of the oil, by coction, is found advantageous in the caſe of bones, it certainly might be rendered ſo, with reſpect to the vegetable ſubſtances on which expreſſion has been already practiſed: and which are now only employed as food for cattle or ſwine: ſince they would, even in this ſtate, afford a much greater quantity of oil, than bones, and of a more valuable kind, with greatly leſs boiling; and, without the troubleſome operation of breaking; which is neceſſary in the caſe of the bones.

EXPERIMENT IV.

Combination of vegetable ſubſtantial oils with lead; exemplified in the caſe of oil of olives.

Take lead, either in its metallic ſtate, in which caſe it muſt be previouſly granulated,—or corroded by vinegar, in the form of ceruſe,—or calcined, in the ſtate of minium, or red lead;—and, having put it into a proper veſſel, add to it twice, or more, its weight of olive oil. Set it then on a briſk fire; and make the oil boil: which will gradually combine with the lead; diſſolving the whole of it, if the mixture be well ſtirred together with a ſtick. By which means, the compound will form a thick ſemi-fluid maſs; that will grow hardiſh when cold: but will be reduced again to the ſame ſoft ſtate by heat.

OBSERVATION.

This extraordinary menſtrual attraction of ſubſtantial oils, with a metal, is peculiar to lead: as there is not any other inſtance of it: for, though rancid or burnt oils will corrode copper, yet no equal ſolution, of that metal, can be made, in a large proportion with the oil, as in this caſe. This combination may, however, be again deſtroyed, either by heat; or by the addition of acids: which, attracting, and combining with the lead, depart the oil. The acid, which moſt effectually performs this, is ſtrong vinegar.

This proceſs has been hitherto extended only to ſome purpoſes reſpecting painting: or to medicinal views, for the formation of a baſis, or principal ſubſtance, to plaſters; and in this application of it, the greateſt care muſt be taken, that the matter do not burn in the operation; which it is, otherwiſe, very apt to do; acquiring thence, not only a brown or blackiſh colour, but a diſagreeable burnt ſmell. To prevent this, the mixture ſhould be ſtirred inceſſantly, while it is kept in the fire: and water ſhould be copiouſly put, along with the ingredients, into the veſſel; and when the firſt quantity is waſted by evaporation, its place ſhould be ſupplied by freſh, till the operation be completed: by which means, the matter will prove white; and be perfectly free from any burnt ſmell. The freſh water ſhould, however, be added before the firſt quantity be exhauſted: or, if it be wholly exhaled, the veſſel ſhould be taken off the fire, and ſuffered to cool, before more be added to the mixture: becauſe, the matter will then be too hot to bear the acceſs of water, without hazard of being blown out of the veſſel by the impetus of the vapour.

EXPERIMENT V.

Combination of vegetable ſubſtantial oils with mineral ſulphur.

Take any ſubſtantial vegetable oil; and, having put it into an earthen veſſel, which can bear a ſtrong heat, ſet it on the fire; and, when the oil is become of a boiling heat, add to it gradually flowers of ſulphur; ſtirring the mixture well together each time, that one quantity may be diſſolved before another be added. By theſe means, the oil may be made to diſſolve about one third of its weight of the ſulphur; and the matter formed of the combined ſubſtances, being of a tranſparent brown colour, and tenaciouſly thick conſiſtence; and is, from its conſequential reſemblance in appearance to vegetable balſams, called *balſam of ſulphur*.

OBSERVATION.

This proceſs is never practiſed, but with regard to medicinal purpoſes: and there the balſam is generally prepared with one fourth, or leſs, of the ſulphur: becauſe, with a greater proportion, it acquires too thick a conſiſtence to pour; which renders it incommodious both to thoſe who retail, and uſe it.

EXPERIMENT VI.

Combination of vegetable ſubſtantial oils, with the ſal ſaponarius.

Take any quantity of the ſolution of the ſal ſaponarius, or the capital lye, which ought to be of ſuch ſpecific gravity, as will ſuſpend a new laid egg, when put into it. To half of it, add ſo much water, as may ſo weaken it, that the egg will readily fall to the bottom: and then put to it an equal weight of olive-oil; ſtirring the mixture about, till the oil be diffuſed among the lye; and the fluid appear white. Set the mixture over a fire to boil gently; and when this firſt quantity is thoroughly united with the oil, add as much of the ſtrong lye, as will amount to thrice the weight of the oil; and continue the boiling, frequently ſtirring the matter, till it become ſo thick, that a drop will concrete, as ſoon as cold, into a firm conſiſtence. Oil, and the ſal ſaponarius ſo combined, form *ſope*: which may be made of oil of almonds; or any other of thoſe ſubſtantial oils, which do not exhale in part, and concrete into a tenacious body, on being expoſed to the air or heat, as thoſe of linſeed or walnuts.

OBSERVATION.

Oils, ſo combined with the ſal ſaponarius, are, in that ſtate, combinable alſo with water: but not with the effect of tranſparency; and, therefore, not according to the moſt perfect effect of commenſtruation. In ſpirit of wine, however, the compound, or ſope, is more perfectly ſoluble; eſpecially if a ſmall proportion of lixiviate ſalt be added.

This combination of oil, and the ſal ſaponarius, may be again deſtroyed by the addition

tion of acid of any kind: which, combining with the alkaline ſalt, departs the oil: but not intirely in its original ſtate. For, contrary to its former nature, it continues to be ſoluble in ſpirit of wine: and is found, likewiſe, to burn more vigorouſly, and produce fewer aſhes. If ſope be decompounded by heat in cloſe veſſels, the oil riſes, being rendered ethereal; and is at firſt of a thinner, and afterwards of more tenacious conſiſtence: the thinner oil being of a reddiſh colour, but that which comes afterwards growing blacker, as it grows thicker.

This proceſs, either in this or a parallel manner, is practiſed, in moſt civilized countries, for making ſope, which, thus prepared from oil of olives, is very hard and white, and of the moſt valuable kind; but there are various methods perſued for the making other ſorts: particularly one kind, in moſt common uſe here, called *ſoft ſope:* in which a conſiderable portion of water is left; and a marble-like or variegated appearance of colours, is produced, by the uſe of certain proportions of ſome impure kinds of lixiviate ſalt, called pot-aſhes, before treated of, page 279, Vol. I.

EXPERIMENT VII.

Combination of the ſubſtantial oils of vegetables with mineral acids; exemplified in the inſtances of oil of olives, and the vitriolic acid.

Take oil of olives, and put it into a glaſs mortar made hot; and having placed it under a chiminey that may take of the fumes, add to it an equal weight with itſelf of ſtrong oil of vitriol. A rapid commenſtrual action will be immediately exerted by the two bodies on each other; manifeſting itſelf by a great ebullition and conſiderable heat, attended with the emiſſion of a very great cloud of black thick fumes, ſmelling like oil and ſulphur burnt. Stir the mixture with a ſtick till the effervеſcence ceaſe: and the two bodies will be found united in a blackiſh red balſam-like ſubſtance of a thick conſiſtence.

OBSERVATION.

The effects of combination betwixt acids, and ſubſtantial oils, are for the moſt part ſimilar to thoſe of this experiment: but there is found, nevertheleſs, ſome variation both from the kinds of acids and oils that are uſed; and alſo from the quantity and manner of mixture. For the heat, which will be generated in proportion to the quantity of the bodies mixt, and the quickneſs in which the mixture is made, reciprocates with the menſtrual action; and they cauſe a mutual augmentation of each other: ſo that on the admixture of a certain portion of each, under due circumſtances, an exploſive degree of heat may be produced, and where inferior degrees are excited, the appearance of the combined matter will vary from the effects of the ſtronger or ſlighter heat, as we ſhall have occaſion to ſee more particularly below.

There is a great difference, as was remarked in the general obſervations betwixt ſubſtantial oils of different vegetables, with reſpect to their commenſtruation with acids: for ſuch as ſuffer a decompoſition by being expoſed to the air, as the oil of walnuts, poppies, and linſeed, approaching nearer to the nature of ethereal oils, commenſtruate much ſtronger with acids than the other kinds, ſuch as thoſe of olives and almonds: and the firſt are therefore rendered more black and thick than the latter, if the quantities ſubjected to the admixture be equal, and the other circumſtances the ſame: or a leſs proportion will produce an exploſive heat.

The nitrous acid being combined with oil of olives, combines with it a peculiar form: appearing of an opake whiteneſs, and of the conſiſtence of pomatum or beaten lard.

Subſtantial oils are decompounded by this combination with acids, in ſuch a manner, that it can never be again ſeparated from them in their original ſtate: and indeed the heat attendant on the commenſtruation conduces to decompound it. The only further decompoſition the compound ſubſtance, produced by this combination, is capable of ſuffering without combuſtion, is, by means of exterior heat: through which it is reſolved into an acid lymph, with the ſmell of a ſulphureous gas; and an ethereal oil: which at firſt riſes of a thin, and afterwards of a very thick conſiſtence, and black colour: and, if the fire be continued after the oil ceaſe to riſe, ſome ſulphur, the ſame with the mineral kind, will ſublime. When the commixture of the oil and acid is made, under ſuch circumſtances, that a much higher degree of heat is generated, the combination is made more perfectly than in this experiment; and doubtleſs a much greater proportion of ſulphur is produced; but the exploſion, that is neceſſarily conſequential to this, diſſipates the matter in ſuch manner, that it cannot become the ſubject of further examination. The ſame may, however, be in ſome degree effected by adding freſh quantities of oil of vitriol, ſucceſſively to the oil brought over: which each time will produce nearly the ſame appearances.

This proceſs is not applied to any commercal purpoſe: the only produce applicable to any uſe (as far as is hitherto known) being the ſulphur: which the low price and ſmall quantity to be thus obtained, put out of queſtion, as a profitable fruit of the proceſs.

EXPERIMENT VIII.

Partial decompoſition, or other changes of the more exalted vegetable ſubſtantial oils, by various means.

Article I. Take oil extracted from linſeed, walnuts, or poppies, and ſpreading it thin on any ſolid body, a part of it will exhale; leaving the remainder in an inſpiſſated glutinous ſtate, after which it will aſſume a concreted form, being tranſparent and hard as a gummous ſubſtance. This decompoſition is ſaid to be promoted by the addition of ſugar of lead, or white vitriol; and is really ſo, in a great degree, by the addition of ſpirit of turpentine, or others of the moſt volatile eſſential oils; — or by long coction with the addition of litharge, minium, or the reſins which are capable of diſſolving in the oils.

II. Take the ſame kind of oil; and keeping it for a long time in any veſſel free from duſt and air, it will grow more colourleſs; and of a thicker and more unctuous conſiſtence: and will then ſooner ſuffer the decompoſition remarked in the preceding article.

III. Or put the oil into a broad veſſel, containing water; in ſuch proportion that the body of oil floating on the water, may be about an inch in thickneſs; and ſet it where the ſun, air, and rain, may have free acceſs to it: continue it in this ſtate, for about three months in ſummer, but double the time in any other part of the year, frequently ſtirring it with a wooden ſpatula; and a decompoſition will be brought about of the oil: one part ſinking to the bottom in a concreted grumous ſtate; and the other part growing perfectly colourleſs and tranſparent: but extremely thick and unctuous.

IV. Take of the above oil, and commixing it, by grinding, with the precipitated earth of alum, left a little ſubacid with ſome of the undecompounded alum, but in other reſpects prepared, by decompoſition of alum, according to Experiment XXI. Sect. III. Part II. Vol. I: or inſtead of the alum uſe the pigments called lake, Pruſſian blue, brown pink, or any other prepared with the earth of alum in this ſtate; and put the mixture into a bladder, or ſpread it as in painting; and a decompoſition of the oil, different from that of article the firſt, will be made. For one part of it will combine with the earth of alum, or of the pigment, and form a tenacious paſty, and very adheſive, ſubſtance: and the other a fluid unctuous matter, like the oils of olives or almonds in their thineſt ſtate; though neither tending to exhale, like that ſubſtance, which ſeparates itſelf in article 1ſt; but remaining a long time in their fluid or moiſt ſtate, till diſſipated by gradual putrefaction.

OBSERVATION.

It is on the principle of the firſt of theſe decompoſitions, that oils of this nature are applied in painting, as the vehicle, and cement of the colouring pigments: which being tempered with them, are thereby rendered of a proper conſiſtence, for being ſpread by the bruſh or pencil: and, in conſequence of the ſeparation, afterwards, of the more volatile part, leaving the other ſolid and tenaciouſly hard, the pigment is cemented or bound down to the ground on which it is laid.

When the oil is prepared, by coction, in order to augment its tendency to this decompoſition,

ſition, either with or without the additions mentioned in the experiment, it is called by painters *drying oil:* and, being mixt with the crude oils, will alſo impart to them this quality in ſome degree; for which end it is conſtantly prepared, and uſed together with ſpirit of turpentine. But where the brown tinge of the drying oil, which is an inevitable conſequence of the preparation by boiling, is injurious to the intended effect of the colouring, oil rendered more prone to this decompoſition through age, mixt with oil of turpentine, and frequently with the ſugar of lead and white vitriol, is employed, inſtead of that attempered with drying oil.

When oils are changed, as according to Article the 2d, with keeping, ſo as to be very ſenſibly more unctuous and thick, than they were originally, they are ſaid to be *grown fat:* and the oil of turpentine, ſugar of lead, white vitriol, ground glaſs, or any bodies uſed in the intention of promoting this decompoſition, are called *dryers.*

The oil changed, by expoſing it to the ſun and air, as above directed in Article 3d, is called *fat oil*, and being afterwards rendered fluid by gentle heat, and filtered through flannel, is uſed for gilding, and ſeveral other purpoſes, with great advantage.

The change produced in oil, by the mixture of pigments, formed of earth of alum in a ſubacid ſtate, is of a very different nature: for inſtead of cauſing that, by which the oil is ſeparated into two ſubſtances, of which the one proves volatile, and exhales, and the other fixt and conſolidated, it divides them into two bodies of a contrary tendency: the fluid part being extremely reluctant to avolation, and the ſolid parts to growing hard. This is called the *fattening* of the paint, or mixture of ſuch oil and pigment; and is a very material fault: as, when found in a more conſiderable degree, it renders the paint wholly unfit for uſe; and incommodious when even in the leaſt. But though this change be in the oil, yet the cauſe of it, and conſequently the pravity, lies wholly in the pigment; for though ſome oils are extremely ſlow in drying; or, indeed, will not dry at all; yet the fattening is always occaſioned by the qualities of the pigment which cauſes this kind of coagulation of the oil. For when oils are neither found to dry of themſelves, nor with the addition of any pigments, or dryers, it may always be juſtly imputed to being commixt through accident, or adulteration, with ſome portion of the oils; ſuch as the olive or almond, that will not dry: which accident, indeed, may eaſily happen, with reſpect to the linſeed oil; as the ſeeds of other vegetables affording the ſame kind of oil, that will not dry, may eaſily be collected with the linſeed, and blend ſuch oil with the other in the expreſſion.

EXPERIMENT IX.

Decompoſition of ſubſtantial oils of vegetables, by heat, on the principle of incaleſcence; exemplified in the caſe of oil of olives.

Take the moſt light ſpongy bricks, that can be found, and having heated them red hot, powder them groſly as quickly as poſſible. Put this powder, while hot, with half its weight of olive oil into a coated retort; and having placed it in an open furnace, lute on a large receiver. Diſtil then with a gradual fire: and a limpid oil will riſe, which will afterwards be ſucceeded by one more thick and brown, which combining with the other, will nevertheleſs be rendered fluid, by means of that. An acid lymph will alſo come over, in a conſiderable proportion. In the retort will remain the bricks; and better than half the weight of the oil, converted partly to coal, and partly to a pitchy oil, that combining with the ſubſtance of the brick, cannot be raiſed without the greateſt force of heat.---Or diſtil a ſmall quantity of the oil *per ſe* in a deep retort, and the ſame ſubſtances will riſe, leaving ſome proportion of coal. The oil ſo obtained, was formerly called *oleum philoſophorum:* and will be thin, light, and of a peculiar diſagreeable ſmell: which imparts itſelf to whatever it touches, in ſuch a manner, as not to be taken away under a great length of time.

OBSERVATION.

The intention of adding the bricks, is only to prevent the overflowing of the oil, into the neck of the retort and the receiver; which is the unavoidable conſequence of an attempt to diſtil ſubſtantial oil, where ſome ſuch method is not uſed, but the oil is ſuffered to remain in a fluid ſtate: in which caſe, after it is inſpiſſated, by the exhalation of ſome part, an exceſſively great frothy intumeſcence is produced. There is conſequently a neceſſity, for employing ſome ſuch intermedium: and bricks uſed in this way are the moſt commodious; as they abſorb the oil, ſo as to prevent its ſwelling with the heat; and when thus prepared, by being previouſly heated red hot, to drive out any heterogeneous volatile matter, they may have contracted, make no other change in the oil; nor add any thing to its proper produce.

This experiment ſhews, that ſubſtantial oils of vegetables are compounded, beſides their proper oleaginous parts, of water, acid, and earth; of which the two firſt are in large proportions: and that their fixity is owing to ſuch acid; as they become volatile, when deprived of it.

This proceſs was formerly practiſed for medicinal purpoſes; in which caſe, inſtead of powdering the bricks, they were heated red hot: and then ſoaked in the oil: no greater quantity being put with them into the retort, than they could imbibe: which method renders the oil, if diſtilled only with the ſtrongeſt heat of a ſand bath, thin, limpid, almoſt colourleſs, and alſo much leſs fœtid; but diminiſhes greatly the quantity. The oil is called modernly *oleum lateritium*, or *oil of bricks*; and is applied to the deſtroying and preventing the breedingof bugs, by rubbing it very ſlightly into the crevices or joints of the wood-work of beds, or other furniture where they may take harbour: and it is found effectual for this purpoſe: but the extremely ſtrong and durable fœtor, makes the uſe of it very incommoding. It may be the moſt cheaply and eaſily prepared for this purpoſe, by the manner directed in this experiment: foulneſs of colour being a matter of indifference in that view; and the ſtrength of the fœtor increaſing its efficacy with regard to this intention.

EXPERIMENT X.

Decompoſition of the ſubſtantial oils of vegetables by heat, on the principle of combuſtion.

Take any ſubſtantial oil; and, having put it in a proper veſſel, fit to it a wick of cotton or paper, as is practiſed for lamps. Light it by ſetting fire to the wick, and the oil will both ſmoak and flame; being partly converted into fumes, that are formed of ſuch portion of the oil, as is rendered ethereal by the heat, but not decompounded further by combuſtion; and partly into thoſe bodies that are produced, as in all other ſulphureous ſubſtances, by the combuſtive action, when in a burning ſtate.

OBSERVATION.

The ſubſtantial oils of vegetables, differ but little in their decompoſition from thoſe of animals: and afford, like them, a peculiar kind of ſoot: which being collected, is called *lamp-black*; and uſed in painting: but the oils of vegetables do not, however, produce ſo large a quantity of this ſoot, as thoſe of animals; and, therefore, are ſeldom uſed in the manufacture of it.

EXPERIMENT XI.

Production of ethereal oil from the ligneous parts of vegetables, by decompoſition through heat, on the principle of incaleſcence; exemplified in the caſe of the wood of guaicum.

Take the raſpings, or ſhavings of guaicum wood; and, having put them into a coated retort, place it in an open furnace; and lute on a large receiver; of which the ſide is perforated with a ſmall hole. Diſtil with a gradual heat, augmented to the greateſt degree: and there will riſe, firſt an acid lymph; and, when the heat is increaſed, a large quantity of ethereal oil; at firſt of a reddiſh colour, and ſo light as to remain on the ſurface of the lymph; but afterwards black and thick; and ſo heavy, as to ſink to the bottom of the receiver. The ſhavings will be found to retain their form in the retort: but to be converted to a perfect coal; that will burn without flame: and which, being incinerated, will be found to have produced aſhes wholly devoid of lixiviate ſalt.

The oil may be ſeparated from the lymph, by means of a proper ſeparating funnel, or tritorium; and will be found to have the qualities of other ethereal oils: and, by repeated diſtillations, may be rendered more thin and volatile.

OBSERVATION.

This diſtillation muſt be managed with great care, with reſpect to the conduct of the fire:

otherwiſe, notwithſtanding the hole in the receiver, the air that is generated in an exceſſive great quantity, will force the lute of the juncture; or burſt the receiver. The heat muſt, therefore, be very gradually increaſed; though at length raiſed to the higheſt point: the black pitchy oil, which comes laſt over, requiring the ſtrongeſt fire to raiſe it.

In the ſame manner, other denſe compact woods, brought from the ſouthern climates, may be treated, with the ſame effect: as alſo other kinds of ligneous matter, but with a various reſult, with reſpect to the proportionable quantities of oil, lymph, and coal afforded: and ſuch as yield much leſs oil, will be found to produce lixiviate ſalts on the incineration of the coal. But in thoſe which produce lixiviate ſalts, only a ſmall proportion of the thin fluid oil afforded by the guaicum, and other woods of the ſame nature, will be obtained.

This proceſs is rarely applied to any practical purpoſe: the oil ſo obtained being at preſent but little uſed, though formerly it was in more eſteem in medicine.

EXPERIMENT XII.

Separation of eſſential oils from the parts of vegetables by expreſſion.

Take the outward rind, pared from the peel of lemons, oranges, citrons, limes, bergamot pear, or of any fruit of a ſimilar kind; and, doubling a piece ſeveral times, compreſs it betwixt the finger and thumb; holding it, at the ſame time, againſt a flat poliſhed glaſs, fixed perpendicularly over a glaſs mortar, or China baſon. The eſſential oil, contained in ſmall ciſts in the rind, will be forced out; and, flying againſt the ſurface of the glaſs, will there, by repeated inſperſions, collect; and form drops; which will fall into the veſſel placed to catch them; and this operation muſt be continued till a ſufficient quantity of the oil be obtained.

—Or take freſh cloves and nutmegs, and having groſsly powdered them, put them incloſed in a piece of linnen into a ſmall ſcrew-preſs, and force out the oil as in the caſe of ſubſtantial oil, and by this means an oil of a middle nature betwixt the ſubſtantial and ethereal oils, will be obtained.

OBSERVATION.

The rinds of the fruits above mentioned, and the ſkins, with ſome few more parts of, or appendages to, others, are the only vegetable ſubſtances, from which perfect eſſential oils can be obtained by expreſſion: the other kind of oil to be procured, as in the preceding experiment, by expreſſion, from the aromatic bodies, not being indued either with the volatility, peculiar odour of the plant, or other qualities, equally with the oils obtained from the ſame ſubjects by diſtillations; and yet have them in a degree not conſiſtent with the nature of ſubſtantial oils. That kind of oil may, therefore, be conſidered as a compound of ſubſtantial and eſſential oils, ſo combined, that the one changes in a certain degree the nature of the other; and both together, thus united, form, as it were, a third genus.

The firſt operation is ſeldom practiſed in this country; as the quantity of oil, to be obtained, does not anſwer the trouble and expence: but a ſimilar, though more effectual method, is uſed in ſome of the more ſouthern countries of Europe, on the rinds of lemon, and the bergamot-pear, for obtaining the oils which are commonly ſold under the name of the eſſence of lemons and bergamot; which are different obviouſly from what can be produced by diſtillation.

EXPERIMENT XIII.

Separation of eſſential oils, from the parts of vegetables, by diſtillation, with a heat not exceeding that which will make a weak ſolution of ſalts, in water, boil.

Take any parts of vegetables; and, having bruiſed or broken them, according as their texture may require, put them into a ſmall ſtill; of which, though they may be the leaves or tops of plants that are very light, they ſhould not fill above one third; and, if they be dry leaves, not above one half: or ſo, in proportion, with other more denſe and heavy matter: for, otherwiſe, being preſt againſt the bottom, they will be burnt. Add as much water to them as will cover them, if the ſtill be full to the greateſt height mentioned; or in proportion for denſer matter: and then, having luted on the head, and fixt a proper bottle or other veſſel, to receive the matter, at the end of the worm, make the water boil briſkly. A milky fluid will be raiſed; and the veſſel receiving it, when filled, muſt be replaced with another: and the operation continued, in this manner, ſo long as the fluid appears to have a turbid whiteneſs: but as ſoon as it appears limpid, the fire may be ſuffered to go out, when only the ſeparation of the oil is in queſtion. Care muſt be always taken, however, not to draw off the water in the ſtill too low; for, in that caſe, the matter would burn; and the oil would acquire an empyreumatic ſmell, deſtructive of the natural odour of the plant: which it ought to bear. The milky fluid, brought over, is the eſſential oil of the plant; which, being commixt with the water, by their condenſing together againſt the ſides of the worm, of courſe cauſes this appearance in it: but, not being menſtrually combined with the water, the oil, of courſe, on ſtanding at reſt, will quit it, by the mutual attraction which its own divided parts have on each other: and, either ſubſiding to the bottom of the veſſel, or floating on the ſurface of the water, according to its greater or leſs ſpecific gravity, will be collected together. The oil muſt, when thus collected, be ſeparated from the water, by means of a proper tritorium; and kept in bottles or phials extremely well ſtopt.

In default of a worm ſtill, any other kind of alembic may be uſed; even a retort in a ſand heat: but that method is not commodious, where the matter affords only a ſmall quantity of oil; and requires a long continued heat to bring it over: the limitation of the quantity of water finiſhing the operation before the whole of the oil be brought over.

OBSERVATION.

This operation is applied to many practical purpoſes, for the obtaining eſſential oils, to be uſed as medicines, perfumes, and in many other ways.

The principal ſubjects of it are, either intire herbaceous plants, or the leaves and green ſhoots, commonly called the tops, of ligneous plants. When theſe are of the annual kinds, they ſhould be gathered at the ſeaſon when the plant is in its full vigour, or juſt beginning to decline, at the extremities: and when evergreens in winter: for, at thoſe ſeaſons, they will be found to afford moſt oil. Being gathered, they ſhould be dried in the air, but in a ſhaded place; and, in order to the rendering them ſtill more ready to give out their eſſential oil, by diſtillation, it is directed, by ſeveral authors of great name, that they ſhould be digeſted for three weeks, with a heat of 90 degrees, in as much water as will overflow them: to which, either ſea ſalt, or oil of vitriol, ſhould be added, in the proportion of half an ounce of the ſea ſalt, or one dram of the oil of vitriol, to a pound of the water. Ageratum, calamint, and ſome few particular kinds, require, nevertheleſs, to be committed to the ſtill as ſoon as gathered: otherwiſe, the oil will not poſſeſs the peculiar ſcent of the plant in its full ſtrength: and though this method of digeſtion has been recommended by Boyle, Homberg, Hoffman, and others; yet it is rarely perſued in practice; unleſs where the oil is of great value, and the matter extremely reluctant to yield it: as the trouble and expence of the digeſtion is not countervailed by the additional proportion of oil obtained. It therefore ſuffices, in general, to put the matter into the ſtill, with the ſalt, or oil of vitriol; and macerate it for ſixteen or twenty four hours; the due proportion of water being added, and kept of a moderate heat: and then to let the diſtillation be performed: but more frequently, where the matter is of no great value, this previous digeſtion is omitted, as alſo the addition of the ſalt, or oil of vitriol. It may be well queſtioned, indeed, whether the ſea ſalt added to the water uſed for the maceration or digeſtion of the parts of vegetables, intended to be diſtilled on the ſcore of their eſſential oil, be really efficacious, in any other way, than by preventing the fermentation, or putrefaction, otherwiſe incident to long digeſtions of the matter; or by rendering the water ſo reluctant to boiling, that a greater degree of heat becoming neceſſary to bring it to that ſtate, a greater attenuation of the oils, and reſinous parts of the matter, and, conſequently, a more perfect ſeparation of the oils from the fibrous parts, are made. For it neither appears that the ſolution of ſea ſalt acts on the oils as a menſtruum, and makes a ſeparation of them, on that principle; nor that it looſens the texture of the ſolid matter to give paſſage to them; but, on the contrary, hardens, and conſtringes it. For herbaceous plants therefore, which have an aqueous ſap, and are of tender texture, diſtillation in water, ſimply, is the moſt expedient; and for the leaves and tops of ever-green plants that abound more in reſinous matter, as alſo for woods, barks, and other parts of ſolid and compact texture, digeſtion, with the addition of the ſalt or acid, may be diſcretionally uſed. This is alſo expedient, in the caſe of flowers, ſuch as thoſe of lavender, orange, roſe, &c. which are ſaid, on the authority of accurate experiments, to afford one third more oil, on being digeſted fifteen days in water acidulated with a little oil of vitriol, than if diſtilled at firſt. It will, however, be found an advantage, in all caſes, to uſe the water, already brought over, or even that remaining in the ſtill, after the operation is finiſhed, inſtead of freſh, (if care be taken, that it neither be fermented nor putrefied): for the water always retains ſome proportion of oil, combined with it, in the form of ſpirit; with which it being ſaturate after one diſtillation, leſs of that of the next will, of courſe, be taken up.

Eſſential oils vary in many particulars: and no regular principle, of ſuch variation, is to be aſſigned, either from the nature of the kinds, or parts of the plants which afford them; for that of the wood of the ſaſſafras, is one of the heavieſt hitherto known; and that of the wood of the fir-tree, one of the lighteſt: that of the flowers of the roſe-tree concretes immediately, in the common coldneſs of the atmoſphere, into an unctuous ſolid maſs; and that of thoſe of lavender, or roſemary, remain perfect fluids: thoſe of the ſeeds of caraway, cummin, aniſe, and others, concrete alſo into unctuous, or ſometimes hard ſolid, maſſes; while that of cloves preſerves a moderately thin conſiſtence. The ſame diverſification holds good, likewiſe, with reſpect to colour, acrimony, and other qualities, which ſeem to have no relation to the other obvious characters of plants. But, with relation to each other, there is a greater correſpondence with regard to two properties; which are, their volatility and gravity: for, it may be taken as a principle, founded on experimental examination, that thoſe are moſt volatile, which have the leaſt ſpecific gravity: though it is by no means a general law of nature, with reſpect to the ſpecies of other generical bodies. It will be found equally true, likewiſe, that the cauſtic acrimony, in eſſential oils, will bear a proportion to the vividneſs and ſtrength of their odour.

Moſt eſſential oils, if long kept, even though the eſcape of the more volatile parts be prevented, are apt to grow thick; and tend to the conſiſtence of balſams: and ſome of them concrete into maſſes of a ſolid brittle nature, like that of camphor before it has undergone a ſublimation. Boerhaave aſſerts on the authority, as he ſays, of perſons of undoubted credit, that the oil diſtilled from the cinnamon, while it is freſh, in the iſland of Ceylon, if kept ſecurely ſtopt for a long time, will be, as to the greateſt part of it, converted into a ſalt, with the true mark of ſpecification, ſolubility in water: and Dr. Slare, likewiſe, affirms, that he was poſſeſſed of ſuch oil; of which, in the ſpace of twenty years, half had aſſumed the ſame ſaline form. I cannot doubt but that there is ſome ground for this notion; and that the oil of cinnamon may depoſit ſome camphor-like concretions; as has been frequently affirmed of it; which concretions may, like the true camphor, have, in their native ſtate, greatly the appearance of ſaline chryſtals. But with regard to their perfect ſolubility in water, I greatly ſuſpect ſome miſtake: though it is poſſible a ſubſtance may be thus produced ſimilar to the flowers of Benjamin; which are capable of being diſſolved in boiling water, though not of retaining that ſtate when cold: and if, therefore, the concreted cinnamon were tried with boiling, it might eaſily give occaſion for the belief of the perfect ſolubility in that menſtruum. But the conſideration of this matter is of too peculiar a nature to dwell upon here: though, I thought this fact too curious, if true, to paſs over it without notice. The colours of eſſential oils vary, as their other qualities, without any aſſignable cauſe: ſome are white, or inclining to yellow:

the greateſt part are brown, either of a ſtronger or more diluted hue, inclining ſome to yellow and ſome to red; and a very few blue; as in the inſtances of yarrow and camomile.

Eſſential oils are applied to various purpoſes, moſt importantly: firſt to medicinal intentions; and next to painting and the formation of varniſhes: and in a leſs material manner, to the preparation of perfumes; and to other uſes. In the medicinal internal uſe, when they are not combined with vinous ſpirit, as we ſhall ſee below, they are commixt with refined ſugar, by pounding the ſugar firſt to an impalpable powder, and then adding to it, the eſſential oil, in the proportion of a dram, or leſs, to an ounce of the ſugar; commixing them in the moſt intimate manner, by dropping the oil gradually into the ſugar, and grinding them, in the mean time, well together. Such a compound of the eſſential oil, and ſugar, is called an *elæoſaccharum:* and may be more elegantly, and expeditiouſly prepared, by adding a ſmall proportion of the white of an egg, during the commixture of the oil and ſugar: but the *elæoſaccharum* is rendered, by this means, leſs proper for keeping a long time.

EXPERIMENT XIV.

Separation of the eſſential oils of vegetables, by diſtillation, per deſcenſum.

Having ground or pounded the matter, from whence the oil is to be extracted, in a glaſs or marble mortar, till it be reduced to the ſtate of a pulp, paſte, or powder, according to its original texture or conſiſtence, ſpread it about half an inch thick on a fine cloth, which ſhould be new; leaving, nevertheleſs, a margin to the cloth not covered with the matter of about two inches depth; and if the matter be hard and reſiſting preſſure, moiſten it, by holding the linnen over the ſteam of boiling water, till it be ſoft and yielding. Put the cloth, with the matter laid upon it, over the open neck of a very large glaſs receiver: and, drawing down the margin of the cloth, tie it round the neck with ſmall pack-thread. The cloth however ſhould not be drawn ſo tight, but that it may, on being preſſed, be forced a little way within the receiver. Place this receiver in any larger veſſel of wood or earthen ware, containing as much cold water as will fill it to the neck of the receiver: and, in order that its being empty may not, as it otherwiſe would, prevent the receiver from ſinking, by its being too boyant, a piece of lead of due weight muſt be fixed to it. A cover of iron or copper, in the form of a ſhallow flat pan, muſt then be put over the mouth of the veſſel, with the bottom downwards; ſo as to compreſs the cloth and matter contained in it within the neck of the receiver; and the cavity of the pan muſt then be filled with hot aſhes; and burning pieces of charcoal muſt be laid on them. By the heat thus produced, and tranſmitted through the bottom of the pan, the matter contained in the cloth will be ſo acted upon, that the eſſential oil will be rarefied into fumes; which, having no other paſſage, will pervade through the cloth into the receiver; and there, being condenſed againſt the ſides of it, rendered more powerfully refrigerating, by their contact with the water in the other veſſels, will form drops that will flow to the bottom. The heat muſt be thus continued, in a gentle degree, till the fumes ceaſe to be emitted: great care being taken, it do not riſe to the degree, that will burn vegetable ſubſtances; which would render the oil black; and deprave its ſcent. The pan and cloth being afterwards taken off from the receiver, there will be found in it lymph; and the eſſential oil of the matter ſubjected to the operation.

OBSERVATION.

This method is rarely employed but for experiment; and then in general only in default of the apparatus proper for that of the preceding experiment: it may, however, be, in ſuch caſe, expediently enough practiſed on cloves, or nutmegs; and moſt kinds of ſeeds affording eſſential oil in a copious manner: as alſo on the peel of oranges, lemons, citron, or the bergamot-pear.

EXPERIMENT XV.

Extraction of eſſential oils from the parts of vegetables by digeſtion in ſpirit of wine.

Take the matter, from whence the eſſential oil is to be extracted, and reduce it to the ſtate of powder, by pounding, if it admit of that treatment; or by raſping, if it be of a ligneous texture; or, otherwiſe, if of a ſofter conſiſtence, bruiſe it till it become of a pulp, or paſte. Put it then into a mattraſs, with vinous ſpirit, of which the proportion muſt be adequate to that of the eſſential oil yielded by the matter: but, in all caſes, it ſhould be ſufficient to riſe two or three fingers breadths above ſuch matter. Invert then a ſmaller mattraſs, or a Florence flaſk, into the neck of the firſt; and place them in a ſand-bath, of a gentle degree of heat; and, when the ſpirit and veſſels have received, alſo, ſo much of this heat as the ſand can communicate to them, lute the two mattraſſes together, by covering the juncture with a piece of bladder ſmeered with the white of an egg. Let the matter then ſtand in digeſtion for ſeveral days; ſometimes ſhaking the veſſels, with due caution not to throw off the upper mattraſs; and the ſpirit of wine, penetrating the matter, will combine with the eſſential oil, and will extract it: which, if the firſt quantity fail to do entirely, a ſecond may be added.

OBSERVATION.

By this means eſſential oils may be extracted from many vegetables, that afford them: and they be eaſily reſeparated from the ſpirit of wine, by the addition of water; which, combining with the ſpirit will depart the oils; and cauſe them, conſequently, to be collected, either on the ſurface of the fluid, or at the bottom of the veſſel, according to their greater or leſſer ſpecific gravity than the compound of the ſpirit of wine and water. But all eſſential oils are not to be obtained by this method, in the ſame ſtate as by diſtillation: ſome of the more groſs and unctuous parts not readily combining with the ſpirit, without the intermediation of a ſtronger heat.

This operation is frequently performed for the preparation of medicines: which are then called *tinctures*: and in ſome inſtances *elixirs*. But it is never uſed practically, for the obtaining the eſſential oils in a ſimple ſtate.

EXPERIMENT XVI.

Combination of eſſential oils with ſpirit of wine.

Take the eſſential oils of a more exalted and volatile kind, ſuch as thoſe of lavender, or roſemary; and, having put them to the vinous ſpirit, freed by rectification,

tion, or other means, below taught, from phlegm or water, ſhake them well together; and they will perfectly combine: or, in the caſe of the groſſer and more heavy oils, ſuch as thoſe of cloves, aniſe-ſeed, &c. diſtil them, together with the ſpirit of wine, in any kind of alembic, with a gentle heat, and the greateſt part of the oil will riſe, together with the ſpirit, perfectly united: leaving, nevertheleſs, a ſmall recrement of an unctuous or reſinous conſiſtence, that will not come over, without ſuch heat as is ſufficient to decompound, ultimately, vegetable ſubſtances.

The ſame effect will follow, if, inſtead of the oil already extracted, any vegetable, affording eſſential oil, be ſubſtituted.

OBSERVATION.

This proceſs is frequently practiſed for medicinal purpoſes, and the preparation of perfuming fluids. But it is moſt uſual to make the combination, by diſtilling the ſpirit of wine with the matter which may afford the eſſential oil, without any previous ſeparation of ſuch oil from the matter. The compounds, formed by this combination, are, in moſt inſtances, called, though improperly, *diſtilled waters*; and in other *ſpirits*. This combination may be deſtroyed; and the eſſential oil and ſpirit of wine reſeparated by the addition of water, which will depart the oil, and cauſe it to float, or ſubſide, according to its greater or leſs ſpecific gravity, than the other fluid.

EXPERIMENT XVII.

Combination of eſſential oils with ſubſtantial oils.

Take any proportion of eſſential and ſubſtantial oils; and mix them, by ſtirring, or ſhaking them together: and they will freely combine.

OBSERVATION.

The combination of eſſential and ſubſtantial oils, is ſeldom practiſed, but in the caſe of oil of turpentine, with thoſe uſed for painting: to which it is added (as was before obſerved) to promote their drying. There is, indeed, one other occaſion, where it is fraudulently done: which is, in the caſe of the oil of cloves, or other eſſential oils of high price, which tend to an unctuous conſiſtence. But this may be diſcovered, when not in a very minute degree, by evaporating two or three drops in a ſpoon by a gentle heat; when, if the eſſential oil be thus adulterated, an unctuous or greaſy reſiduum, very ſenſibly different from what would be left by any ſuch oil alone, will be found: a gentle heat effecting a perfect decompoſition of the compound ſubſtance formed by the combination of eſſential and ſubſtantial oil. They may, likewiſe, be reſeparated by the addition of ſpirit of wine, which, combining with the eſſential oil, will depart the ſubſtantial.

EXPERIMENT XVIII.

Combination of eſſential oils with reſins; exemplified in the caſe of oil of turpentine; and maſtic, or ſanderac.

Take oil of turpentine; and, having put it in a phial, add to it maſtic, or ſanderac, in any proportion not exceeding one third of the weight of the oil. Put the mixture into a phial, and place it in a ſand-bath, or on brick made hot in the fire; where it may receive a heat ſufficient to make it boil. Continue it in this ſtate till the ſolid matter be diſſolved.

OBSERVATION.

In like manner many other reſins may be diſſolved in oil of turpentine; and alſo in oil of lavender, roſemary, and others of the more exalted eſſential oils. But neither do all reſins admit of being combined with eſſential oils, nor all eſſential oils with the ſame reſins.

This proceſs is practiſed for the preparing ſome kinds of varniſhes; which have the advantage of thoſe made of ſolutions of reſins in ſpirit of wine, in not *chilling*, as it is called; that is, growing dull and cloudy, as the menſtruum leaves the reſins: but they are inferior to ſome others made with ſpirit of wine, of the lac, and other reſinous bodies of a harder texture; which are ſoluble in ſpirit of wine, but will not admit of ſolution in eſſential oils.

The analyzation of this compound may be effected by gentle heat: which will exhale the eſſential oil from the reſin: but not without robbing the reſin, if of the native kind, of ſome portion of that oil, which it contained, as part of its own proper elements.

EXPERIMENT XIX.

Combination of eſſential oils with lixiviate ſalts; exemplified in the inſtance of oil of turpentine.

Take the pure lixiviate ſalt obtained from any vegetable; and, having heated it red hot, put it into a glaſs mortar: and then powder it as quickly as poſſible; and inſtantly pour on it, gradually, an equal weight of oil of turpentine, rubbing them well together till the oil diſappear; and be perfectly united with the ſalt.

OBSERVATION.

The ſalt and oil may, by this means, be ſo perfectly combined, as to unite with water, like ſope formed with ſubſtantial oil. This proceſs is not, however, practiſed for any other than medicinal purpoſes: and that but rarely at preſent: though it was formerly more in uſe under the name of the ſapo philoſophorum, and, according to ſome, Starky's ſope: but it was then prepared by the tedious method of deflagrating tartar, with nitre, in order to the obtaining the lixiviate ſalt; and afterwards of combining the oil, with the ſalt in a moiſt ſtate, which required a conſiderable length of time, and much trouble.

EXPERIMENT XX.

Partial decompoſition of eſſential oils, by diſtillation, and other means.

Take any quantity of eſſential oil; and, having put it in a cucurbit, ſet it in balneo mariæ, and, fitting on a head, diſtil with a boiling heat. The moſt volatile and thin part of the oil will riſe; and leave a reſiduum; which will be of the conſiſtence, and, alſo, much of the nature, in other reſpects, of native balſams. If the oil be kept ſome time, and this be repeated, another

other portion of the ſame balſamic ſubſtance will be produced: by which means, the quantity may be at length greatly reduced: and if the balſamic matter, left after theſe diſtillations, be put into a retort, and diſtilled with a ſtrong heat, a mixt black, light, earthy matter will be left.---Or take any quantity of eſſential oil, and diſtilling it ſeveral times with water, the ſame effect will be obtained: the oil being likewiſe proportionably deprived of its peculiar ſcent and flavour.---Or take any eſſential oil and ſhake it for a long time in water; and the peculiar ſcent or flavour will be tranſmitted to the water; that combining with the odorous ſpirit, in which thoſe qualities reſide, ſeparates it from the eſſential oil.

OBSERVATION.

It appears by the reſult of theſe operations, that eſſential oils are reſolvable, by diſtillation, into ethereal oils and reſin: and that the oils again grow reſinous by keeping: as alſo that they may be partially decompounded by their intimate commixture with water, either through the means of diſtillation or concuſſion; the water depriving them by its ſuperior attraction of the odorous ſpirit. Theſe ſeveral properties ſhew, that they are not compounded of elements equally combined with each other, but that the phlogiſton, or acid, is more abounding in certain parts than others: in conſequence of which, ſome, being more volatile, are ſeparated by the heat from the others; which afterwards aſſume, conſequently, another form.

This decompoſition is ſaid to be much promoted, by the addition of chalk or lime. Mr. Bourdelin, according to Du Hamel's hiſtory of the royal academy of ſciences at Paris, decompounded five ounces of oil, by mixing it with chalk, and diſtilling it from, and cohobating it upon, the chalk eight times, into two ounces and one dram of oil; two drams and forty-five grains of ſalt; and half an ounce of lymph, ſtrongly impregnated with ſalt. Mr. Homberg likewiſe aſſerts, that by commixing one pound of eſſential oil, with lime firſt quenched in water, and afterwards rendered thoroughly dry, and diſtilling and cohobating it ſixty times, he obtained fifteen ounces and a half of water; and one ounce of oil. Mr. Boyle, on the other hand, affirms, that by repeated diſtillations, he converted a pound of eſſential oil almoſt wholly into earth. From Bourdelin's experiment, as related, we might juſtly believe that oil was conſtituted of water and ſalt, with ſome other principles, that either maintain their form of oil, under repeated diſtillations; or would be converted into water and ſalt by a continued repetition of them. According to Boyle's experiment, nearly the whole ſubſtance of oil is conſtituted of earth: and according to Homberg's, the far greateſt part is water. The different accounts are too contradictory to be any way reconciled, if they were true; and there were no fallacy in the experiments taken in this view: for it is abſurd to ſuppoſe, that the ſame ſubſtance can contain ſo much ſalt, water, and earth, as, taken together, greatly exceed its proper weight; or that the ſame ſubſtances ſhould be converted, by the ſlight variations in the manner of theſe experiments, into bodies ſo different as ſalt, water, and earth, are from each other. Nothing, therefore, can be inferred from theſe accounts, with reſpect to the conſtituence of eſſential oils, when they are conſidered jointly: and there is, I think, good reaſons alſo for not making ſuch uſe of any of them taken ſingly. In Mr. Bourdelin's experiment, there is no room to conclude, that the ſalt was a part of the oil: but that it was formed by combination of part of the chalk with the acid in the oil: which, making an ultimate decompoſition of that part of the oil of which ſuch acid was an element, would either cauſe the phlogiſton to eſcape from the earth, and force its way out of the veſſels; or to form ſome new combination with the chalk itſelf. This, therefore, though a decompoſition, is not ſuch an analyſis of the oil, as can give light into its conſtituence: part of the elements not being, perhaps, by any method recoverable from the maſs of the medium employed, and the other recoverable only in a combined ſtate with part of the matter.

The ſame holds good of Mr. Homberg's account; and, if it were certain, that he had ever made the experiment, and found the reſult to be as he related, it would be moſt reaſonable to believe, that the oil was fixt by its combination with the lime, either in its intire, or in a decompounded ſtate; and that the water was principally afforded by the lime, notwithſtanding the previous drying of it. But I cannot help doubting the facts of this experiment, along with ſeveral others related by Mr. Homberg; which have, after many repeated trials, by the moſt able perſons, been found extremely different. I am extremely ſorry to be obliged to confeſs the ſame of Mr. Boyle in this, and ſeveral other inſtances, with reſpect to chemical experiments; for I am well aſſured, as well from the experiment itſelf, as from many collateral certain principles and facts, that near a pound of earth, or even an ounce, or ſtill much leſs proportion, is not to be ſeparated from that quantity of any eſſential oil whatever; for though ſome recrement will be left, after ſeveral repeated diſtillations, and more particularly if the oil be kept a long time betwixt each, yet the diminution of the remaining oil will always be in a much greater proportion, than the weight of the earth, to be obtained from this recrement; as in that analyſis, which frees the earth from the remaining oil, an adequate portion of the acid, water, and phlogiſton, the other elements of the oil, are ſeparated from it. I have dwelt, however, upon this ſubject, in ſo minute and particular manner, in order to remove the objections that might ariſe, againſt what I had advanced with reſpect to the conſtituence of ethereal oils, from the experiments related on the authority of ſuch eminent perſons; and which, notwithſtanding their apparent contradiction to, and incompatibleneſs with, each other, Boerhaave has thrown together, even in the ſame page, to manifeſt the conſtituence of eſſential oils: appearing to give himſelf, and expect from others, a great degree of credit to each.

The proceſs of this experiment, which regards the diſtillation of oils *per ſe*, in balneo mariæ, or with water in any common alembic, is practiſed for the correction of eſſential oils, when grown thick with keeping, or when diſpoſed to be viſcid, or mucilaginous, after their ſeparation from the vegetable matter whence they were obtained: but it is recommended by ſome, eſpecially in the latter caſe, to grind them thoroughly well, with three times their weight of ſea ſalt, in a marble or glaſs mortar, before they be diſtilled.

EXPERIMENT XXI.

Decompoſition of eſſential oils by combuſtion.

Touch eſſential oils, with any body heated luminouſly hot: and, taking fire, they will continue to flame of themſelves, the air having acceſs to them, till their whole ſubſtance be diſſipated.

OBSERVATION.

This experiment ſhews, how wide it is from truth, that the far greater part of eſſential oils is formed of earth: for there is no inſtance of any body, containing a large proportion, that will exhale away, by the heat generated from its own combuſtion. For if the quantity of earth in any body be large, comparatively to that of the phlogiſton, a medium is neceſſarily wanting, by which the whole of ſuch earth may be rendered volatile; and the greateſt part conſequently remains fixt, notwithſtanding the action even of intenſe heat. It appears, therefore, that in eſſential oils, in their intire ſtate, there is only a ſmall portion of earth, in compariſon of the whole quantity of the oil: but in the reſiduum left after the diſtillation, where that part which contains a larger proportion of phlogiſton riſes, and leaves that which contains a leſs, the quantity is greater. But even this reſiduum on burning affords but little; which ſuggeſts a difficulty of conceiving, how Mr. Boyle, in the experiment mentioned in the obſervations on the preceding article, could convert almoſt any part of the oil to ſimple earth; unleſs he called the reſin, or coal, which, according to the different degrees of heat employed, will be left after the diſtillation, by the name of earth.

EXPERIMENT XXII.

Separation of the odorous ſpirit, from the parts of vegetables, by diſtillation.

Gather the plant, or part of a plant, from whence the odorous ſpirit is to be obtained, in a mature ſtate, early in the morning, with the dew upon it. Put it, in this condition, without bruiſing it, or adding any other moiſture, into a ſmall alembic; and place the alembic in balneo: fixing on its proper head; and a glaſs receiver. Let a diſtillation be made of what will riſe with the heat of eighty five degrees of Farenheit's thermometer: and a lymph, containing in it the odorous ſpirit of the vegetable matter, will come over.

OBSERVATION.

It is only theſe parts of plants, in which the odorous ſpirit is combined with water, that are proper for this operation: for, in many others, that ſpirit is only found in a combined ſtate with the eſſential oil; and not to be obtained in this manner: as in the bark, ligneous ſubſtances, fruit, ſeed, &c. The herbaceous plants, or the leaves or tender green ſhoots of flowers of ligneous plants, therefore, are the only matters fit to be ſo treated; and in theſe, of many ſpecies, this ſpirit is wanting, at leaſt in a ſenſible degree. The real quantity of odorous ſpirit is, moreover, extremely minute in the lymph, when impregnated with it in the higheſt degree producible by art: for if it be ſuffered to be ſeparated by the air from the water, in conſequence of leaving the veſſel containing it unſtopt, there appears to be no ſenſible diminution of the quantity of fluid, through its abſence: but, being ſo combined with the water, as not to be ſeparated, unleſs through the means of air, in which caſe it is neceſſarily diſſipated, there is no method of collecting it in a ſimple ſtate, nor even in a more concentrate ſtate in the lymph. But, though the matter of the odorous ſpirit ſeems extremely ſmall, the powers are great: for to it, not only the peculiar ſcent and flavour of moſt plants are owing; but the medicinal virtues likewiſe of many kinds: and the cauſtic acrimony of eſſential oils, ſeems likewiſe the effect only of this ſubſtance in a more collected ſtate; as it always bears proportion, in ſuch oils, to the ſtrength and vividneſs of the odour of them; which depend on the proportion of this ſpirit in them. As there is no means of obtaining this extraordinary ſubſtance, but in a combined ſtate with oil or water, it cannot be made the further ſubject of experimental examination, otherwiſe than with reſpect to the comparative degree of menſtrual attraction it has to theſe bodies; and the qualities it poſſeſſes in a combined ſtate with them. Theſe qualities are, its conſtantly preſerving the ſcent and flavour, with which it characterizes the plant from whence it is originally obtained; and its producing acrimony in eſſential oils; and in ſome caſes even in expreſſed oils; as in that of muſtard-ſeed; if the pungent flavour and ſmell revived in that oil, on the addition of vinegar, be not owing to ſome proportion of eſſential oil, combined by the mediating power of ſome third body, which is ſuperſeded by the action of the vinegar on it; as before explained, p. 96.

This proceſs is ſeldom practiſed, unleſs to obtain waters, to be uſed as perfumes, from orange flowers, roſes, &c.: though it is recommended by Boerhaave in a medicinal view; and was formerly a conſiderable article in pharmacy. But the quantity of impregnated water yielded, by the vegetables, this way, is ſo ſmall; and the eſſential oils are in general ſo much more copiouſly afforded by the ſame plants; both poſſeſſing, as far as is diſcoverable, the ſame medicinal virtues in a much ſtronger degree, and retaining them much longer than ſuch waters; that this operation ſeems comparatively unprofitable and ineffectual to the end, when practiſed, in the intention of obtaining medicines.

EXPERIMENT XXIII.

Separation of the odorous ſpirit from the parts of vegetables, by the menſtrual attraction of vegetable ſubſtantial oils.

Take roſes, the flowers of jaſmine; or any other flowers, or leaves, of a ſtrong fragrant ſmell; and, having put them in a bottle with a wide neck, fill the bottle with the oil of olives, or any other ſcentleſs vegetable ſubſtantial oil; and lay a piece of bladder over it. Set the bottle in the heat of the ſun in ſummer; or in any other gentle heat; and let it remain ſo for a month, ſometimes ſhaking it briſkly. The bottle being then opened, the oil will be found to have attained the odour of the matter infuſed in it; and, being ſtrained off from it, may be added to a freſh quantity, if it be deſired to impregnate it more ſtrongly with the odorous ſpirit; the ſame treatment being repeated.

OBSERVATION.

By this means, the odorous ſpirit may be attracted by ſubſtantial oils, from the flowers, leaves, and other parts of plants of tender texture,

ture, which may be penetrated by them: and they will retain it much longer, when expoſed to the air, than water impregnated with it.

This method is frequently uſed for the perfuming oils, with the ſcent of flowers, or of other odoriferous parts of plants of a tender texture: but it is generally practiſed, after the infuſion, to give the oil and infuſing matter a gentle coction; which renders the operation more effectual to this end. But I omitted that addition to the operation; as being eluſive of the end of the experiment; which is to ſhew the attraction of ſubſtantial oil, with reſpect to the odorous ſpirit. For, by the coction, the eſſential oil, in the vegetable matter is ſo rarefied, that it burſts its cells; and forcing its way out of them, commixes itſelf with the ſubſtantial oils, and impregnates them conſequently with the ſpirit contained in it: rendering the experiment therefore equivocal; as not being concluſive, that the odorous ſpirit was attracted by the ſubſtantial, ſince that which is found in it might be only ſuch as reſided in the eſſential oil; the combination of which eſſential oil with the ſubſtantial, was not any part of the view of the experiment.

EXPERIMENT XXIV.

Separation of the odorous ſpirit from the ſubſtantial or eſſential oils of vegetables, by the ſuperior menſtrual attraction of water.

Take a quantity of any eſſential oils of vegetables, which are endued with a ſtrong fragrant ſcent,—or of any ſubſtantial oil impregnated with the odorous ſpirit, in the manner directed in the preceding experiment;—and having put it into a common bottle, add to it about twenty or thirty times its weight of water; taking care, nevertheleſs, that the bottle may not be above three fourths full. Stop the bottle ſecurely with a cork; and then ſhake it for a long time together, and frequently, for ſome days: and ſeparate afterwards the oil from the water, by the uſual methods: and the water will then be found to have acquired the fragrant ſmell of the oil; which, if the ſhaking together be repeated a ſufficient number of times, will be in a great degree deprived of it.

OBSERVATION.

This experiment proves the ſuperior attraction of water to vegetable oils, with reſpect to the

the odorous ſpirit, by its depriving them of it on their intimate commixture; but it is not applied to any other purpoſes.

EXPERIMENT XXV.

Separation of the odorous ſpirit from water, by the ſuperior menſtrual attraction of air.

Take the water, diſtilled from the proper parts of plants, according to Experiment XXII; or impregnated with the odorous ſpirit in the manner directed in the preceding;—and expoſe it to the air in an open veſſel. In a few days it will loſe its peculiar ſcent and fragrance; and bear no remaining marks of the preſence of the odorous ſpirit, with which it was impregnated.

OBSERVATION.

This proves the ſuperior menſtrual attraction of air to water, in relation to the odorous ſpirit: for, though the deprivation, which the water undergoes of the ſpirit by this means, is generally aſcribed to its volatility; yet it is evident, that it is owing to ſome other principle; when the fact is conſidered, of its not riſing from water in cloſe veſſels, even with a conſiderable degree of heat compared to that in which it exhales with the admiſſion of air. For, if this ſpirit quitted water ſolely by its volatility, it would be practicable to concentrate it by proper diſtillation even to a great degree; which is, on the contrary, found not practicable: as, in cloſe veſſels, it does not appear to be ſeparable from a certain proportion of water which always riſes with it on the application of heat. Some other principle, therefore, being neceſſary to account for the exhalation of the odorous ſpirit from water when expoſed to the air without any concomitant ſenſible quantity of water, recourſe muſt neceſſarily be had to the attractive power of the air with regard to it: ſince there is no other known medium of the ſeparation of bodies menſtrually combined, but volatilization, and departure by ſuperior menſtrual attraction.

This treatment of water, impregnated with odorous ſpirit, is of no practical uſe; as it can only tend to diminiſh the value of the odoriferous water: but as an experiment, it demands regard, ſince it appears from hence, and the two preceding experiments, that the odorous ſpirit may be attracted from plants, by ſubſtantial oils; and that it is attracted from oils, either ſubſtantial or eſſential, by water; and from water, by air. But what further analyſis it ſuffers in the air, or what tranſmutations it undergoes, either in the impregnation of other vegetables of a ſimilar nature or diſtinct genus, or by entering into the conſtituence of other natural bodies, experiment falls wholly ſhort of the means of exploring.

EXPERIMENT XXVI.

Separation of ſpirit of wine from fermented liquors.

Take any fermented liquor, produced according to Experiment VII. Sect. III; and, having put it into any kind of alembic, diſtil with a moderate heat, ſo long as the fluid appears to come over tranſparent: but, if the diſtillation be longer continued, a whitiſh lymph, ſomewhat acid, and of a diſagreeable taſte, will riſe; containing little or no ſpirit; and depraving that which was before come over. The tranſparent fluid, ſo obtained, will be the vinous ſpirit, formed by the fermentation of ſaccharine matter; but yet diluted with a great quantity of water; and combined with ſome proportion of ethereal oil and acid, not properly belonging to its own conſtituence.

OBSERVATION.

The production of vinous ſpirits was before explained in Experiment VII. Sect. III. and the obſervations on it, in ſhewing the converſion of any ſolution (naturally or artificially made) of the ſaccharine matter into a fermented liquor:

in which the vinous ſpirit exiſts in a combined ſtate with the water;—ſome portion of vegetable acid;—an ethereal oil of a peculiar nature, that is united with the water, by means of the ſpirit and acid;—and a conſiderable proportion of earth, with ſome oil of a cruder and more fixt nature, which does not riſe till decompounded by a ſtronger degree of heat. The preſence of the ethereal oil and acid in fermented liquors, is manifeſted by their riſing partly with the ſpirit, and partly after it, with the remaining lymph which then comes over; and that of the cruder oil and earth, by their appearance, on due examination in the recrement left after the diſtillation; but though there is always a conſiderable quantity of theſe ſubſtances in fermented liquors; yet the proportion varies greatly, according to the kind of matter fermented. The ſpirit being ſeparated by diſtillation, is not free from a portion of the ethereal oil and acid; and it is this which, varying according to the kind of the fermented matter, renders vinous ſpirits, obtained from different ſubjects, ſo different in their ſmell and flavour, when they have undergone only one diſtillation: and which occaſions their bearing the different names, before mentioned, of brandy, rum, &c.

The ſpirit, thus obtained by one diſtillation, is generally too much diluted with water, to exert its menſtrual qualities on reſins, eſſential oils, and other bodies; water when combined with ſpirit beyond a certain proportion, which may, on good grounds, be ſuppoſed to be an equal quantity, rendering it rejective of ſuch bodies; and even departing them from the ſpirit if it be added after the combinations.

This proceſs is practiſed on many kinds of fermented liquors, for the production of brandy, &c.: but moſt frequently here on the fermented liquor of corn: the ſpirit obtained from which by the firſt diſtillation is called *the low wines:* but, when rendered by rectification, of ſuch ſtrength that it will diſſolve eſſential oils, *proof ſpirit*; which may be known to be of that, or a greater ſtrength, by its combining perfectly with the more exalted oils, when commixt with it, by ſhaking them together.

EXPERIMENT XXVII.

Rectification of vinous ſpirit with, or without, additions.

Take vinous ſpirit, as obtained in the preceding experiment; and, having put it into any kind of alembic, diſtil with a gentle heat, ſo long as the ſpirit comes over nearly of equal ſtrength; but, when it appears to be weaker, diſcontinue the operation. The ſpirit obtained, by this method, properly conducted, will be of that ſtrength called *rectified ſpirit* of wine:

of which the criterion commonly received is, that it will fire gunpowder. In order to dephlegmate the ſpirit, yet more perfectly, a third or fourth diſtillation is neceſſary: and when thus, or by any other means, it is freed from water in the moſt perfect degree, it is called *alcohol.*

In order, the more eaſily to obtain alcohol, take vinous ſpirit once rectified; and, having heated pure lixiviate ſalt red hot, and powdered it as quickly as poſſible, add it, in that ſtate, to the ſpirit, in the proportion of an ounce to a pint. Stop then the bottle containing the ſpirit ſecurely, and ſhake it for a conſiderable time. When it has been afterwards ſuffered to ſtand ſome little time at reſt, the water, with a part of the ſalt diſſolved in it, and the other part of the ſalt, in an undiſſolved ſtate, will be ſeen at the bottom of the veſſel: and the ſpirit, from which the greateſt part of the water, before combined with it, will be thus ſeparated, will be collected together; floating on the ſolution of the ſalt. The ſpirit ſhould then be ſeparated, by pouring it off from the ſolution and ſalt; and, a freſh quantity of the ſalt being added, the ſame ſubſequent treatment ſhould be repeated: and this ſhould be done a third or fourth time; if it appear needful, from the moiſtening of the ſalt laſt added. But the quantity of ſalt may be reduced to half, after the ſecond time. By this means, the ſpirit will be freed from the far greateſt part of the phlegm or lymph before combined with it; and, conſequently, be converted into alcohol. But a very ſmall proportion of lymph, nevertheleſs, remaining, it will ſuſpend a part of the lixiviate ſalt diſſolved in it; and, by that means, render the alcohol impure, and even deprave it for ſome practical uſes. In order, therefore, to ſeparate this ſalt from the ſpirit, or to deſtroy its alkaline quality, if any extreme minute quantity ſhould remain, take a dram of alum powdered very finely; and put it into the alcohol; and, having well ſhaken the veſſel, let it ſtand at reſt, till the alum be ſubſided, and then pour off the alcohol from it. By this means, the alkaline ſalt, in the alcohol, will be converted by the vitriolic acid of the alum into the neutral ſalt, called the *ſal polychreſtus*: which, requiring much more water to its ſolution, than the lixiviate, will, of courſe, be departed; or, if an extremely minute proportion yet remain, its alkaline qualities will be intirely deſtroyed by the neutralization it will undergo from the acid of the alum: and the alcohol will be, therefore, almoſt wholly freed from any ſaline impurity: or, that which remains will be prevented from depraving it, either by acid, or alkaline properties; both which render it unfit, as well for ſome practical, as for experimental purpoſes.

OBSERVATION.

The vinous ſpirit freed from phlegm to that degree in which it will fire gunpowder, when thrown upon it in a flaming ſtate;—or in which, when put into a ſpoon and accended, it will burn away ſo intirely, that no traces of moiſture ſhall be left on the ſpoon;—is rendered capable of diſſolving moſt ſulphureous bodies, that are capable of combining with ſpirit of wine. It is ſaid, likewiſe, that when further dephlegmated to the ſtate of alcohol, it will diſſolve

amber,

amber, and ſome other of the harder bituminous or reſinous bodies. But on many repeated trials, by all the methods propoſed for the ſolution of amber, (not previouſly compounded by heat,) in ſpirit of wine, I never could effect it; nor have ever been able to obtain any ſuch ſolution from others, who have taken great pains to accompliſh this work: they having acknowledged to me, that they have met with the ſame failure of ſucceſs with myſelf. Though alcohol does not, therefore, appear to have any menſtrual attraction with many more bodies than the common highly rectified ſpirit of wine: yet it is uſeful in many inſtances, on the ſcore of its leaving the bodies diſſolved in it without any aqueous moiſture, when exhaled from them: which renders it particularly advantageous, in the compoſitions of ſuch varniſhes as are formed of reſins diſſolved in vinous ſpirits: as this depuration of the ſpirit from water prevents their *chilling*, as it is called; and renders the varniſh more effectual in producing the gloſſy effect with a leſs number of coats.

Boerhaave commends the addition of a few drops of oil of vitriol, to be uſed, for the correction of the alkaline quality of alcohol prepared by means of lixiviate ſalt. But the ſubſtitution of alum is certainly a great improvement: for though the oil of vitriol will anſwer the end; and would not be injurious, if only ſo much could be added, as would exactly ballance the alkaline ſalt: yet, it being impracticable to adjuſt the quantity ſo truly, either the effect will not be wholly anſwered by its uſe, from the addition of too ſmall a quantity; or more than will be neutralized by the alkali, will be introduced; in which laſt caſe, not only an acid quality will be imparted to the alcohol, equally injurious to the purity of it with the alkaline: but the vinous ſpirit itſelf will, in ſome degree, be decompounded, (as we ſhall ſee below), if any remedy be ſought for this, by the addition of more alkali. The alum, therefore, is much to be preferred for this purpoſe: becauſe it operates with equal power in converting the lixiviate ſalt into the ſal polychreſtus; as ſuch lixiviate ſalt, being of a ſuperior degree of attraction in the alkaline genus, departs the earth, which is its baſis from it; and combines with the acid, as if added to it in a ſimple ſtate: while, at the ſame time, all ſuch part of it, as is not neceſſary to this end, remaining in a ſolid ſtate, is, of courſe, ſeparable from the alcohol by the moſt eaſy means, as it quickly ſubſides to the bottom of the containing veſſel, on ſuffering it to ſtand at reſt.

The part of this experiment which regards the rectification of ſpirit of wine without addition, is practiſed conſtantly for the rectification of ſuch ſpirit for medicinal uſes; the burning in lamps; the preparation of varniſhes; and many other purpoſes. But the preparation of perfect alcohol, either by ſimple rectification, or by dephlegmation through the addition of other bodies, is rarely practiſed but for experimental applications. Though there was, however, a medicinal proceſs, formerly in uſe, for combining lixiviate ſalt with alcohol, by means of commixture as in this experiment, and ſubſequent digeſtion of the ſpirit and ſalt together; by which means, the ſpirit acquired a reddiſh brown colour; owing rather to ſome change produced in it from its own partial decompoſition, by the ſalt of tartar, than from its borrowing any thing from that ſalt. It was, however, improperly called *tincture of ſalt of tartar*: from an erroneous ſuppoſition, that a conſiderable portion of the ſalt was combined with the ſpirit.

EXPERIMENT XXVIII.

Combination of vinous ſpirit with eſſential oils.

See Experiment XVI.

EXPERIMENT XXIX.

Combination of vinous ſpirit with reſins.

Take any of the reſins that will diſſolve in ſpirit of wine; and, having powdered them groſsly, add to them ſix or eight times their weight of ſtrong rectified ſpirit of wine. Place the bottle, containing the mixture, in a gentle heat; and ſhake it frequently for ſeveral days: and the reſin will, in that time, be diſſolved; and the ſolution may be purified, by filtration, from the fæces, if any appear.

OBSERVATION.

In this manner may be diſſolved, the common reſin obtained from turpentine; ſanderac; maſtic; ſome of the hard white reſins, that paſs under the names of gum animi or copal; gum lac of both kinds; myrrh; dragon's blood; the yellow reſin abounding in the root of turmeric; and many others. Several of the chemical writers have directed, that the gum lac, myrrh, and others, ſhould be previouſly combined with lixiviate ſalt: but this will be found not only unneceſſary, if the ſpirit of wine be of due ſtrength; but is even detrimental to the produce when deſigned to be uſed, as a laquer for metals; or for many other purpoſes.

The combination of reſins and vinous ſpirit, may be eaſily deſtroyed by the addition of water to the ſolution: as ſuch water, attracting the vinous ſpirit, deſtroys the attraction, it before had with the reſin; which, being departed, is precipitated to the bottom of the veſſel.

This proceſs is frequently practiſed on the harder, and ſometimes on the ſofter, reſins, for the preparation of varniſhes, and laquers; and particularly on the gum lac, of which two kinds are brought from the Eaſt-Indies: the one under the name of *ſeed lac*, the other of *ſhell lac*. Theſe ſubſtances are not, indeed, native reſins; but they are the reſinous parts of plants, collected by ants to form their niduſſes, which are fabricated in a very peculiar manner, in long cluſters, on the ſmaller branches of trees. Being of a very tenacious and firm texture; and diſſolving without difficulty in ſpirit of wine; they form a very common and uſeful varniſh on ſome occaſions alone; and, in others, mixt with other reſins. Solutions are, likewiſe, frequently made of reſins in this manner, for medicinal purpoſes: in which caſe, ſuch ſolutions are called *tinctures*, as thoſe of myrrh and Benjamin. The tincture of Benjamin is alſo prepared as a perfume: and, a precipitate being made from it by the addition of water, it is uſed as a coſmetic, and is called *lac virginis*.

EXPERIMENT XXX.

Combination of vinous ſpirit with ſope, formed either of ſubſtantial or eſſential oils.

Take ſpirit of wine, of that degree of ſtrength called *proof ſpirit*; and, having put it into a proper bottle or phial, add to it one third of its weight of Caſtile ſope, cut into thin ſlices. Set it in a gentle heat; and, after it has ſtood ſome time (the veſſel being ſhaken) it will be perfectly diſſolved.

Or take alcohol; and put into it a ſixth of its weight of the ſope, formed as in Experiment XIX. of lixiviate ſalt and eſſential oil; and, treating it in the ſame manner, it will be diſſolved.

OBSERVATION.

In ſome caſes, where the proportion of alkaline ſalt in the ſope is inſufficient, or where the ſpirit of wine abounds in acid, the ſolution of the ſope, formed of ſubſtantial oils, may be rendered more perfect by the addition of a ſmall quantity of lixiviate ſalt; which may be added gradually, if the ſolution appear milky, and defective, (ſhaking the veſſel,) till it appear to have had its due effect.

This proceſs, with reſpect to the firſt part, is frequently practiſed for medicinal uſes; and the ſolution was formerly in much repute, under the name of *opodeldoc*: but it is ſeldom employed, at preſent, in regular practice.

The ſolution of the ſope of the eſſential oil, is ſeldom made, unleſs for experiment.

EXPERIMENT XXXI.

Combination of vinous ſpirit with the ſal diureticus, or neutral ſalt formed of lixiviate ſalt and the acid of vinegar.

Take highly rectified ſpirit of wine: and add to it one ſixth part of its weight of the terra foliata tartari, or ſal diureticus, as prepared in Experiment I. Sect. III. Part II. and obſervations on it. Let them digeſt for ſome time in a gentle heat; and the ſalt will be perfectly diſſolved, leaving only a ſmall proportion of fæces.

OBSERVATION.

This is one of the few ſalts, which ſeem to combine with ſpirit of wine: for though the volatile alkaline, and moſt other kinds, be diſſolved in weaker ſpirit; yet it is the water, and not the vinous ſpirit, which commenſtruates with them; as appears on the adding alcohol to ſuch ſolutions, which departs a proportionable quantity of the ſalt; and evinces, that inſtead of commenſtruating with it, they tend to render the water rejective of it. The tinctures pretended to be made of tartar, ſalt of tartar, and the tartar tartariſutus, or ſoluble tartar, are, therefore, not properly ſolutions of the ſalts; but either decompoſitions in part of ſuch ſalt, by taking from them ſome of their oleaginous matter; or of the ſpirit, in the caſe of the ſalt of tartar, according to ſome; who imagine, that ſpirit of wine may be gradually decompounded by the addition of freſh quantities of lixiviate ſalt through its action on the acid in the conſtituence of it. But there is nothing hitherto determined by adequate experiments, on this point, to give room to ſay any thing deciſive with regard to it.

EXPERIMENT XXXII.

Combination of vinous ſpirit with oil of vitriol, and its conſequential decompoſition.

Take rectified ſpirit of wine; and drop into it an equal weight of ſtrong oil of vitriol: taking care, nevertheleſs, only to add a very ſmall quantity each time; and to let the mixture cool, as it will each time grow hot, before more be added. When the whole is commixt, after ſtanding at reſt for ſome days, during which time it will acquire a reddiſh colour, let it be put into a retort; and diſtilled in a ſand bath, with a degree of heat ſufficient to keep the fluid in a boiling ſtate. A limpid tranſparent fluid, reſembling the ſpirit of wine, will riſe; and along with it, another of an oily light nature, but perfectly colourleſs: which will, nevertheleſs, combine with the other, as they commix in the receiver. After about eighteen ounces are come over, if one pound weight of each kind of matter be put into the retort, or in proportion with reſpect to other quantities, the peculiar odour of the fluid will begin to change into the ſuffocating ſmell, that attends the burning of mineral ſulphur, or the diſtillation of vitriol: at which time change the receiver; but continue the diſtillation: and an acid lymphous fluid will riſe; which, after ſome time, will be accompanied with a yellow, reddiſh, or greeniſh oil; that will, at the end of the operation, be partly ſuſpended on the ſurface of the lymphous fluid; and partly ſubſide to the bottom. When the greateſt part of this fluid is come over, the matter in the retort will begin to ſwell in a black froth; which, without great care in ſuppreſſing the fire, will come over into the retort. It is, therefore, beſt when this intumeſcence can be no longer reſtrained

ſtrained without great hazard, to diſcontinue the heat; and leave the remaining part of the matter in the retort: which, on its being taken out, will be a black matter, ſomewhat moiſt, and of a ſweetiſh ſour ſmell, reſembling that of ſugar of lead. Add, to this matter, a freſh quantity of rectified ſpirit of wine, as before, but in a leſs proportion: and, the ſubſequent treatment being repeated, the ſame effect will follow; only the ſpirit obtained will be more fragrant than the firſt.

The black matter may be, otherwiſe, further analyzed, by putting it into a very tall body; and diſtilling it with a ſlow heat; in which caſe, oil of vitriol, ſmelling ſtrong of a ſulphureous gas, will come over: and a black dry pitch-like maſs, of a truly bituminous nature, will be left: which will, nevertheleſs, be ſoluble in ſimple ſpirit of wine; in the ſpirit obtained in the diſtillation from the oil of vitriol and ſpirit of wine; and in the ethereal oil which makes a part of that ſpirit: tinging them all of a reddiſh colour. The diſtillation of this matter is, however, very tedious; as, notwithſtanding the height of a very tall body, it is ſtill apt to riſe with a foaming ebullition into the head: and where, therefore, it is not required to have the bitumen in a pure ſtate, the analyſis may be equally well made with the addition of white chryſtalline ſand, previouſly waſhed, firſt in oil of vitriol, to free it from all impurities that are capable of being diſſolved in that menſtruum; and afterwards in water, to cleanſe it from the oil of vitriol; and then dried: in which caſe, the ſand will no other way act on the matter, than by preventing its, otherwiſe, ſcarcely reſtrainable ebullition. This bituminous matter being commixt with lixiviate ſalt, and afterwards ſubjected to diſtillation, affords a reddiſh oil, ſimilar, in all reſpects, to that afforded by foſſile bitumens: or, being put into a crucible, and expoſed, with the acceſs of air, to a burning heat, it will firſt flame, then glow, for ſome ſhort time; and, at length, the other part being conſumed, leave a ſmall portion of aſhes, or white earth.

The fluid which came over, compounded of the ethereal oil and ſpirit, is called *ſpiritus vitrioli dulcis*; and by ſome *ſpiritus napthæ*: and it may be further decompounded by the ſeparation of the ethereal oil from the ſpirit: which muſt be thus performed. Add double the quantity of water to the ſpiritus vitrioli dulcis; and drop into them, gradually, a ſolution of pure lixiviate ſalt: and ſhake the veſſel briſkly containing the mixture: the oil will then be departed from the ſpirit; and, collecting together, will float on the ſurface, and may be then ſeparated from the ſpirit, either by decantation, through the means of a proper tritorium; or by diſtillation with a gentle heat.

The oil, thus ſeparated, is that kind commonly called *æther*, or the *ethereal ſpirit of Frobenius*: and the remaining fluid will reſemble ſpirit of wine diluted with water; and is ſaid to vary from its original ſtate, only in containing more phlegm: but if it were more ſtrictly examined, than it appears to have been hitherto, it will, moſt probably, be found to be different in other points alſo.

The groſſer oil, which riſes with, and after the acid lymph, is called by ſome *oleum napthæ*; and is of the ſame general nature with the æther; having its fragrant aromatic odour, and many other of its qualities: but being much leſs volatile, and more heavy; and wanting ſome other properties peculiar to æther: all which variations ſeem to ariſe from that large proportion of acid in its conſtituence, which is apparent, by the effervescence conſequent to the addition of alkaline ſalts. It may be decompounded by ſimple ablution in water: repeated quantities of water becoming acid, on being ſhaken with it in a proper veſſel; and its quantity being proportionably diminiſhed: but a more effectual decompoſition is made by diſtillation, after the addition of alkaline ſalts: only a ſmall proportion being then to be recovered. This oil may be alſo decompounded, as others, by combuſtion: flaming, when accended, till the whole be conſumed.

OBSERVATION.

In the proceſs for the production of æther, given by Mr. Beaume to the academy of ſciences, and republiſhed in a late work, which agrees, in general, with that of this experiment, as to other particulars, it is directed to mix the ſpirit of wine and oil of vitriol together; and to ſhake the veſſel: but, if this be done, there will be the greateſt hazard of an exploſive heat; eſpecially, if both the ſpirit of wine and oil of vitriol be perfectly dephlegmated, as he directs. For I have ſeen the accident happen more than once on the commixture of ſmall quantities: which have, on the ſudden addition of the acid to the vinous ſpirit, blown up in flame, to the danger and annoyance of the operator.

The proportion of oil of vitriol, here directed, is not neceſſary for the production either of the ſpiritus vitrioli dulcis, or æther: but it is expedient, in order to obtain the greateſt quantity in the leaſt compaſs; and to produce the other phænomena after the æther and ſpirit be raiſed, as well as to ſhew more extenſively, the effects of the decompoſition of the vinous ſpirit.

It appears, in the reſult of the experiment, that, by this treatment, part of the ſpirit of wine is decompounded: the oleaginous ſubſtance, of which it is in part conſtituted, being ſeparated from the lymph; and alſo from the vegetable acid; as ſuch acid muſt be preſumed, from the analogical neceſſity of its preſence, as a medium of combination of the oleaginous and aqueous ſubſtances, to have a ſhare in the conſtituence of vinous ſpirit. The ſecondary ſeparation of the æther from the diſtilled ſpirit, by lixiviate ſalt, after the diſtillation of the compound, formed by the oil of vitriol and ſpirit of wine, is eaſily explained: but the primary decompoſition of the vinous ſpirit, by the oil of vitriol, in which the æther is originally ſeparated, is not eaſily to be accounted for; as it appears a kind of paradox, that lixiviate ſalt, which is the medium of this ſeparation, ſhould not produce the ſame effect, on the ſpirit of wine, before the commixture of the oil of vitriol with it, as it does after. A late writer has taken upon him to explain this matter, by ſaying, that the attraction of the vitriolic acid, both on the oil and water, is the cauſe of the decompoſition; and that the æther is only vinous ſpirit depraved, by being robbed of part of the phlegm, which is neceſſary to its conſtituence in a perfect ſtate. With regard to his accounting for the decompoſition on ſuch principles, he is certainly right, as far as regards what he ſays of the attraction of the oleaginous part by the vitriolic acid: but, with regard to that ſhare of the effect which he gives to the action of the acid on the water, I conceive he is miſtaken, as the attraction of the water, by the oil of vitriol, ſeems to have very little concern in the matter. For no ſeparation of the oil from the water is actually made, even by diſtillation, if the whole, which comes over, be ſuffered to commix, without the mediation of alkaline bodies; and he does not ſo much as touch on the difficulty I have juſt mentioned, with reſpect to the reaſon, why lixiviate ſalts, added to the ſpirit which firſt comes over, or to the oil which riſes with the acid lymph, ſhould ſeparate the æther from the ſpirit, and the groſſer oil from the acid combined with it; and yet have no power to ſeparate them from the lymph, or the acid, in the original ſtate of the ſpirit, that is before the addition of the vitriolic acid. This may, however, be ſatisfactorily accounted for, by the change of the nature of the acid, which follows on the addition of the oil of vitriol, in the conſtituence of the ſpirit; and the difference of the kinds of combination, alſo, which are produced by it. For that acid, by its ſuperior attraction of the oleaginous parts of the ſpirit of wine, diſpoſſeſſes the original vegetable acid; and takes its place; making, however, no further decompoſition or change in the general combination: the whole of ſuch oleaginous part remaining yet in the form of a ſpirit, that is commiſcible with water. But the vitriolic acid, in this ſtate, being ſubject to be attracted by alkaline ſalts, more powerfully than by the oleaginous matter, with which it is thus combined, quits it on their addition; and leaves it, conſequently, free to reaſſume its proper form: which accordingly happens to the part, moſt perfectly exalted by the fermentation, producing the æther; and the other groſſer parts, the leſs volatile and heavier oils; and even ſome proportion of fixt ſulphur; which is found in the coal; but which was, nevertheleſs, before rendered volatile, by the combination of the whole together in the ſpirit of wine. This conſequence of the change of the acid, in rendering the combination ſubject to be deſtroyed by the addition of alkaline ſalts, though it was not ſo before ſuch change, is to be accounted for, by the analogical properties of theſe bodies. For, in the compounds made by the operations of nature in the vegetable œconomy, the acid is, in many inſtances, ſo combined with oils and earth, that it is rendered either wholly neutral to alkaline ſalts; or, otherwiſe, it commenſtruates with them, without ſuffering any ſeparation from the other elements; as in the inſtances of ſugar, tartar, and ſubſtantial oils; but when mineral acids, or even vegetable acids by means of art only, are combined with any other ſubſtances, except phlogiſton under thoſe circumſtances where mineral ſulphur is produced, lixiviate ſalts always depart them, when added under the circumſtances proper for commenſtruation. It is, therefore, conſiſtent with the properties of ſimilar bodies in other inſtances, that this difference ſhould be found betwixt the ſpirit, when decompounded with reſpect to its original acid, but regenerated, as it were, by acceſſion of the vitriolic, and the ſpirit itſelf in its primary ſtate: as the ſame difference is found, in other inſtances, betwixt thoſe bodies where the combinations are made, by nature, of the vegetable acids with oils and earth; and thoſe made through means of art, with either mineral or vegetable acids: and premiſing this principle, the whole of the phænomena, in that decompoſition of the ſpirit, by which æther is produced, may be ſatisfactorily explained. This decompoſition of vinous ſpirit affords, therefore, that extremely exalted oil called *æther*, other ethereal oil of various degrees of a groſſer or leſs exalted nature, and water; with ſome earth, either entering into the conſtituence of the groſſer oil in the ſpirit, or combined in its ſimple ſtate, with the oils and other elements, in the general conſtituence of the ſpirit; and ſhews, demonſtratively, that ſpirit of wine is compounded of lymph and oil, in various degrees of exaltation, from the moſt ethereal, that has hitherto been collected by art, to ſuch as is ſo groſs, that, being combined with the vitriolic acid, it requires a very great degree of heat to raiſe it: and even then, moreover, ſome part will remain, which will not be raiſed by any heat of culinary fire; but yield earth, on its incineration. It alſo preſumptively ſhews, that the ſpirit contains a conſiderable quantity of vegetable acid: ſome acid being analogically neceſſary to the conſtituence of all ſpirits, or oleaginous matter ſo modified as to commenſtruate with water: but whether the earth obtained, be only a part of the leſs exalted oil, or be conjoined with the other elements by their combined attraction, is not to be determined.

The æther, thus produced, has the true properties of eſſential oils, according to the principles of ſpecification, above given, of ſuch oils, in the general obſervations on the parts of vegetables; or compared with others, according to their general qualities, in any different view: varying from them, only in thoſe particulars, which are the neceſſary reſult of its being more exalted. The aſſertion, therefore, that æther is only ſpirit of wine depraved, by the loſs of ſome part of the water neceſſary to its conſtituence, ſeems, therefore, very inadvertent: for allowing, that the difference of ſpirit and æther, lay only in the privation of the water, which, with reſpect to their conſtituence, is not, however, the fact, ſince æther, according to this gentleman's own principles delivered in other places, muſt be, alſo, deprived of that acid which he makes the conſtant medium of ſuch combinations of oleaginous matters with water; yet the eſſential and ſpecific qualities being changed, and the ſubſtance rendered ſimilar, in thoſe produced in the change, with another diſtinct ſpecies, it is certainly an impropriety to call ſuch ſubſtance, ſpirit of wine degenerated by the loſs of its phlegm, or half decompounded; inſtead of ſaying, that it is, an ethereal oil produced by the decompoſition of the ſpirit of wine. Æther, indeed, is ſo far from preſerving a middle nature betwixt ethereal oils, and vinous ſpirit, in the view in which this gentleman conceives the matter, that it varies in the extremeſt degree from ſuch ſpirit; and evidently contains leſs water than any other known oil: for if, as he himſelf ſays, ſpirit of wine is a compound of oil, water, and acid, and that the water is the heavieſt principle in it, the æther, being much lighter than any other oil, muſt be certainly concluded to contain leſs, and not more water; and, conſequently, to recede further from the nature of ſuch ſpirit, when its difference from oils is placed in their having a larger proportion of water in its conſtituence.

Mr. Hellot, in ſome experiments and obſervations on the production of æther, has affirmed, that the oleum napthæ, or oil which riſes in the diſtillation with the laſt acid lymph, will be heavier or lighter, and different, likewiſe, with reſpect to colour, according to the proportion of oil of vitriol added to the ſpirit of wine: being boyant on the water, and colourleſs, when the quantity of oil of vitriol is leſs than one third of the weight of the ſpirit of wine,—yellow, and diſpoſed to ſink when it is half,—and greeniſh, and actually ſubſiding when it is equal. But this is one of thoſe hypotheſes, with which the memoirs of the French academy of ſciences abound, that are pretended to be founded on the experiment of the promulgator; but which, when examined experimentally by others, will be found to be groundleſs.

He has aſſerted, alſo, that the quantity of this oil may be augmented, by adding any ſubſtantial oil to the other ingredients, before the diſtillation, in the proportion of three or four ounces to two pounds of the ſpirits, and oil of vitriol, and that it may, likewiſe, be prevented from coming over at all in the diſtillation, by the addition of dried potter's clay: the æther and ſpirit continuing to riſe to the laſt without it. The world is greatly obliged to that ingenious gentleman for this improvement, and manner of conducting the proceſs, which, when this addition is made, he directs to be thus. Let the quantities be one pound of ſpirit of wine, eight ounces of oil of vitriol, and four ounces of dried potter's clay, or in proportion, to be digeſted together for three or four days; in which time, the mixture does not turn reddiſh, as when the potter's earth is omitted. Let the diſtillation be then made, in a ſand bath, with a moderate heat; and continued, as long as any thing can be raiſed, with this degree of heat. The æther, remaining ſpirit, and phlegm, being thus brought over, and continuing mixt in the ſtate of a ſpirit, a tall glaſs body, with a head made in one piece, in the top of which is a hole, muſt be procured: and, the ſpirit being poured into it through the hole, the hardeſt well water, that can be obtained, muſt be alſo added, in the proportion of twice or thrice the weight of the ſpirit; and, if there be any appearance of acidity in this ſpirit, from its taſte, two or three drams of lixiviate ſalt muſt be added. The æther muſt then be diſtilled from the water and ſpirit of wine, by a lamp heat; and will aſcend like a white column, through the fluid, as long as any remains. After this leſs perfect ſeparation of it from the ſpirit, let it be put into a long bottle, with an equal quantity of hard well water; and the bottle be well ſhaken. The mixture will, at firſt, appear milky: but the æther will ſoon ſeparate, and float on the water; with which it will no more admit of any union; but may be ſeparated by a ſyphon. This experiment of Mr. Hellot's illuſtrates the explanation, before given, of the manner of decompoſition of the ſpirit of wine in the production of æther: for the alkaline earth in the clay commenſtruates with the combined oil of vitriol, and oleaginous ſubſtances of the ſpirit of wine; of which oleaginous ſubſtance the greater part is ſo fixt by it, that it will not riſe, as otherwiſe it would, with a moderate heat: but the moſt exalted part, that forms the æther, being extremely volatile, the degree of attraction, it has with the acid and earth, is not ſufficient to reſtrain it under the action of heat. From theſe reaſons, neither the groſſer oil, nor the acid, combined with the æther, are brought over, as in the other experiment: but the æther may be freed by ſimple diſtillation, and ablution in water, when the proceſs ſucceeds perfectly, without the addition of lixiviate ſalt; though it is neceſſary in the proceſs where the clay is omitted.

The proceſs of this experiment, as far as regards the commixture of the oil of vitriol, and ſpirit of wine, and the diſtillation of them, is frequently practiſed for preparing the ſpiritus vitrioli dulcis for medicinal uſes, particularly for the preparation of *Vigani's elixir of vitriol:* which is a compound of this ſpirit, with the eſſential oil of mint, and the green colour of the blades of corn; or of ſome other herb, capable of imparting it to this mixture. *Hoffman's drops* are alſo nothing more than the ſpiritus vitrioli dulcis prepared in the manner of this experiment, but with a leſs proportion of oil of vitriol; and combined with the oleum napthæ. The proportion of oil of vitriol to the ſpirit of wine uſed in that caſe, is one third, fourth, fifth, or even ſixth, of the acid, to one of the ſpirit: and the proportion of the oleum napthæ to the ſpiritus vitrioli dulcis, is ſix drops of the oil to one ounce of the ſpirit. The part of this proceſs, which regards the further preparation of the æther, is alſo now become a part of the pharmaceutic chemiſtry; being admitted to have a place in ſome authoriſed Pharmacopeias: but it is not, as far as I know, applied to any other purpoſes, unleſs in an experimental view.

EXPERIMENT XXXIII.

Combination of vinous ſpirit with ſpirit of nitre, and the conſequential decompoſition.

Proceed as in the foregoing experiment: only ſubſtituting fuming ſpirit of nitre for oil of vitriol; changing the relative proportion to eight parts of the ſpirit of nitre, to one of the ſpirit of wine.---Or add the ſpirit of nitre, to the ſpirit of wine, in an equal meaſure; and put the mixture into a long bottle, or phial, very ſecurely ſtopt; and letting it ſtand for about a fortnight, an ethereal oil, limpid, and almoſt colourleſs, will be found floating on the ſurface, in the proportion of about a ſixth part of the whole. This ethereal oil being ſeparated by decantation, and freed from the acid contained in it, by dropping gradually into it a few drops of the ſolution of lixiviate ſalt, will greatly reſemble in its qualities the æther obtained by the decompoſition of vinous ſpirit, through the means of the oil of vitriol. Or the oil may be ſeparated from the remaining ſpirit by diſtillation.

OBSERVATION.

In the firſt part of this experiment, the ſame appearances will not occur, as in the preceding. For that which correſponds with the oleum napthæ will riſe before the ſpirit; and the whole will be free from the gas-like ſmell mixt with the fragrance; which fragrance will here be much greater alſo; and the reſiduum will be ſpirit of nitre not changed but by dilution: or, if the ſpirit of nitre be ſtrong, and the proportion added, do not exceed one third or fourth, the whole will come over without any reſiduum. The late writer above mentioned has, however, aſſerted, that a thick liquor remains after the diſtillation, which he ſays was found by Mr. Pott, to yield on re-diſtillation, by ſtronger heat, an acid liquor, and ſome drops of an empyreumatic oil; and a black ſhining charred matter. But ſuch reſiduum, when found, muſt be attributed to the impurity of the ſpirit of nitre; which, being prepared by means of green vitriol, or oil of vitriol, generally contains ſome proportion of the vitriolic acid, till purified by means of ſilver: and if, as I preſume it might moſt probably be, that, which was employed in the experiments that have given ground for this aſſertion, was in ſuch ſtate, it would neceſſarily occaſion theſe appearances. But if the ſpirit of nitre be pure, and the ſpirit of wine highly rectified, the whole will come over intirely, when they are combined in due quantities: as I have ſeveral times ſeen, when thirty or forty pounds weight have been diſtilled in the ſame retort.

The ethereal oil, produced by the meer commixture of the ſpirit of nitre, and ſpirit of wine, is in ſome degree analogous, as to its general nature, with the naptha obtained from the vitriolic acid and ſpirit of wine, by diſtillation; but, nevertheleſs, from the whole of its qualities, particularly its lightneſs, and volatility, it may be eſteemed of a middle nature, betwixt the naptha and æther; and being freed from the acid combined with it, by the addition of lixiviate ſalts, will afford an æther ſimilar to that of the other. The action of the ſpirit of nitre on the vinous ſpirit, in the production of this oil, is the ſame with that of vitriolic acid before explained: the ſpirit of nitre, by its ſuperior attraction of alkaline bodies, expelling the vegetable acid before combined with it: and the reaſon why the oil, in this caſe, ſeparates from the remaining fluid; and floats on the top of it; (which is not found in the other,) is moſt probably owing ſolely to its ſpecific gravity; which diſpoſes it to riſe before ſuch a proportion of the nitrous acid be combined with it, as would render it, both by the addition to its gravity, and menſtrual diſpoſition, commiſcible with the water. For if, after it has thus collected in a ſeparate body on the ſurface of the other fluid, it be ſuffered to continue there for ſome time, it will gradually appear to diminiſh in quantity: and be at length all taken up again by the other fluid: and this will happen even in a ſhort time, if they be frequently commixt by ſhaking; which brings the oil more effectually in contact with the acid. The oil may, nevertheleſs, be again recovered in the form of æther, either by diſtillation, or the addition of lixiviate ſalt.

EXPERIMENT XXXIV.

Combination of vinous ſpirit with ſpirit of ſalt.

Proceed as in Experiment XXXII. as far as reſpects the commixture, and firſt diſtillation;

tion; only ſubſtituting the ſpirit of ſalt for the oil of vitriol.

OBSERVATION.

The effects of this combination are not correſpondent to thoſe of the vinous ſpirit, with oil of vitrol, and ſpirit of nitre: for neither the fragrant ſmell, nor decompoſition, are the conſequence of it: and this is probably cauſed by the diluted ſtate of the ſpirit of ſalt; which, from its fuming qualities, when in a more concentrate ſtate, does not admit of its being freed from the phlegm, in ſuch proportion as would render it capable of acting more powerfully on the vinous ſpirit. This proceſs is, therefore, ſeldom practiſed at preſent, but as an experiment, though it has a place in the pharmacopeias, the produce being called in pharmacy the *ſpiritus ſalis marini dulcis.*

EXPERIMENT XXXV.

Combination of vinous ſpirit with vinegar.

Proceed as in Experiment XXXII. as far as reſpects the commixture, and firſt diſtillation; only ſubſtituting vinegar for the oil of vitriol.

OBSERVATION.

The vinegar has yet leſs effect, than the ſpirit of ſalt, on the vinous ſpirit: and it can ſcarcely be decided, whether menſtrual combination, or meer commixture, be the reſult of putting them together: though, from the conſideration, that the vinegar is raiſed in the diſtillation, in a greater proportion, than is correſpondent with its volatility, comparatively to that of the ſpirit of ſalt, it may juſtly be preſumed that there is ſome menſtrual union betwixt them. The not acting more powerfully on the vinous ſpirit may be accounted for in the vinegar, on two principles: the firſt of which is, its being unavoidably in a very diluted ſtate; the other its not being of a rank, in the ſeries of attraction of acids, ſuperior to the acid which is a conſtituent part of the vinous ſpirit: as that is either the ſame, or of a ſimilar nature; and, conſequently, has no power to effect ſuch a decompoſition, by departing the conſtituent acid; as happens in the caſe of the vitriolic and nitrous kinds.

This operation, therefore, is ſeldom practiſed, unleſs where it is made a part of the proceſs, in the counterfeiting French brandy, by other vinous ſpirit; in order to which it is ſometimes uſed, along with other ingredients, ſome proportion of coaly matter being left in the retort.

EXPERIMENT XXXVI.

Decompoſition of vinous ſpirit, by combuſtion.

Take alcohol; and, putting it into a deep veſſel, ſet fire to it; and place under any proper veſſel (ſuch as is uſed for the diſtillation of ſulphur) where the vapour produced may be condenſed. The alcohol, if of due ſtrength will intirely flame away; leaving no reſiduum: and ſuch part of the vapour, as is condenſed, will be found to be meer phlegm with an empyreumatic taſte and ſmell.

OBSERVATION.

This experiment determines, that ſpirit of wine is compounded of phlogiſton, and a large proportion of water; and if of earth, only in ſuch quantity as the phlogiſton may render volatile, by a ſlight degree of heat, even under the decompoſition that the ſpirit of wine ſuffers in the combuſtion. The preceding experiments evinced demonſtrably, that the phlogiſton exiſted in the ſpirit, combined with the proper elements for forming ethereal oils; with which it was compounded into ſuch oil, under various circumſtances; as appears from the groſſneſs of ſome parts, and the exalted ſtate of the others, obtained by the decompoſition, and preſumptively, moreover, of ſome proportion of vegetable acid; which is the medium of combination of the oil with water ſuperadded.

This experiment ſhews, that beſides the phlogiſton and acid, a large proportion of water enters the conſtituent parts of vinous ſpirit, in the moſt dephlegmated ſtate. But this is not peculiarly eſſential to the nature of ſpirit of wine: for eſſential oils, when burnt, afford alſo a conſiderable quantity of water: which indeed ſeems to be a general principle or conſtituent of bodies of this kind; eſpecially thoſe which are of a very fluid and thin conſiſtence.

EXPERIMENT XXXVII.

Separation of the anomalous ſpirits of vegetables by diſtillation; exemplified in the inſtance of pepper-mint.

Take dried pepper-mint and water, in the proportion of two ounces to a pint of water: and, having put them into an alembic of any kind, diſtil off, with a gentle heat, as much as can be raiſed, without danger, that the herb may burn to the veſſel. The fluid brought over will be the anomalous ſpirit of the ſubject matter combined with water.

OBSERVATION.

By the ſame means, balm, penny-royal, worm-wood, angelica, and many other herbs, afford anomalous ſpirits; but with various properties, with reſpect to taſte, flavour, and medicinal operation. But there is one kind of this ſpirit mentioned before in the general obſervations on the part of vegetables, which has very peculiar qualities: and is found of a ſimilar nature,

ture in very different plants, and parts of plants; as it is to be obtained moſt copiouſly from the leaves of laurels; and, alſo, in a leſs proportion from the kernels of the ſtones of black cherries, and of peaches and other fruit; and ſeveral more parts of various vegetables. This ſpirit is of an extremely deleterious nature, when not in a diluted ſtate: that, procured from the leaves of laurel, like the oil of bitter almonds obtained by diſtillation, with which it has the greateſt affinity in taſte and ſmell; inſtantly killing dogs, or other large animals, when taken even in a ſmall quantity.

The ſpirit, that may be thus ſeparated from the parts of vegetables, ſeems to differ from eſſential oils in nothing, but that there is ſuperadded to them ſome other ſubſtance, which ſerve as a medium to combine ſuch oils with the water: as from thoſe parts of vegetables that afford theſe ſpirits copiouſly, the eſſential oils are either not to be obtained at all, or only in a ſmall quantity. But this ſuperadded body is nevertheleſs ſo united to them from the time of their original production, as not to admit of any ſeparation from them, without the decompoſition of the eſſential oil itſelf alſo. This mediating ſubſtance may be, analogically to the formation of vinous ſpirit, concluded to be the vegetable acid combined, in the more volatile kinds, with a leſs proportion of earth; and, in the more fixt, with a greater (even ſometimes to the degree that produces a ſaline nature): ſo that they might be

divided

divided into two ſubgenera, the *volatile*, which as we ſee below, like that of peppermint or laurel leaves, will riſe in diſtillation with the water; and the *more fixt*, which like thoſe of galls, and tea, will endure a conſiderable heat without riſing. There is, indeed, beſides theſe, ſome proportion of ſpirit of this kind to be obtained from moſt parts of vegetables, that yield eſſential oils copiouſly: as we ſee in the caſe of the ſeeds of dill, and many other kinds; in the peels of oranges, lemons, and the other ſimilar fruits; in Jamaica pepper; in cinnamon; and in many others: but the ſpirit afforded by the parts of plants, thus abounding in fragrant and aromatic oils, is neither, with reſpect to the quantity or qualities, like that afforded by the other kinds deficient in eſſential oil. The yielding either the one or the other, appears indeed to be in general a diſtinct characteriſtic property in the plants: and, it is probable, that the ſpirit, obtained from thoſe abounding greatly in eſſential oil, is only ſuch oil exiſting in its original ſtate; but combined accidentally with the water, in the operation by which it is ſeparated from the plant, either, when found in that which is raiſed in the diſtillation, by the odorous ſpirit previouſly attracted by the water; or, when found in the reſiduary water after the diſtillation, by the acid or ſalts imparted to the water; and not originally combined in the plant, with that which is the medium of its combination with the water. Care ſhould, therefore, be had, in the conſiderations on experiments regarding this kind of ſpirit, to diſtinguiſh, as far as may be, that kind which is the conſequence of the ſtate of the ſulphureous bodies in the plants themſelves, from the other kind, which is the reſult of an accidental union of the eſſential oil with the water, in the operation, by ſome adventitious medium; which, though it might be imparted to the water, by the ſame vegetable matter in which the oil reſided, was not yet before in a ſtate of combination with the oil.

EXPERIMENT XXXVIII.

Separation of reſins from the parts of vegetables, by liquefaction through heat.

Take ſound pieces of old fir, or pine, trees, of a proper ſize; and put them into a large earthen body pot, with a narrow neck, filling the body or pot ſo, that the pieces may bind each other. Let it be then placed in any kind of furnace, or oven, where the whole of it may be heated; being fixt in ſuch manner, that the mouth of the neck may be depending in ſuch manner, as to ſuffer any fluid to run freely out from the cavity of it; a proper veſſel being placed, as a receiver, to catch what may be diſcharged. Let a fire be then gradually raiſed in the furnace: and the reſinous and balſamic parts will be liquefied; and run from the pot into the receiver; but great care muſt be taken not to ſuffer the heat to exceed the due point, that will make the reſin flow. When the liquefied matter ceaſes to come freely with this degree of fire, remove the veſſel ſet to receive it; and, having put another in its place, raiſe the fire; and an aqueous vapour will riſe, and at the ſame time the remaining part of the reſin will flow out; but burnt to a black colour: and when this ceaſes to flow, the receiver muſt be again changed: after which, by augmenting the heat to the ſtrongeſt degree, a yet more burnt kind will be obtained. The matter thus obtained in the two firſt veſſels will be in a middle ſtate, betwixt balſams and reſins: but, being evaporated in a proper pan over the fire, or in a ſtill, with or without water, will attain the hardneſs and dryneſs of reſins. The firſt kind, when obtained in this manner from fir, and ſuch other, trees as afford it copiouſly, is not any otherway diſtinguiſhed than by the general name of *reſin*;

the ſecond kind, while in the unctuous ſtate in which it is ſeparated from the wood, is called *tar*: and this kind rendered dry by evaporation, and alſo the laſt kind, as it is obtained from the wood, are called *pitch*.

OBSERVATION.

Reſins are, alſo, obtained in a native ſtate from many plants, of which the balſams, exuding, exhale by the heat of the ſun to a dry ſtate. They are, alſo, obtained by the artificial evaporation of balſams: as is conſtantly practiſed, in the way of diſtillation, on turpentine, for procuring the eſſential oil; when the reſiduum left is a reſin of the ſame nature, as that obtained by the proceſs of this experiment; except, that if (as is now generally done,) water be put to the turpentine, the reſin will be more white and firm, than that ſeparated from the wood by a greater degree of heat, as in this experiment, which is unavoidably neceſſary to that end.

This proceſs is performed in Germany, and other countries, for the production of reſin in very great quantities: a large kind of oven, with a proper trough channel, leading from it to a large receiving veſſel, being uſed inſtead of the body or pot in the experiment; and a large furnace being built round the oven to ſupply due heat to the wood put into it. The converſion, by evaporation of the balſamico-reſinous matter, firſt flowing, into hard reſin, and of the tar into pitch, is made in large kettles: but might, with much greater advantage, be done in the way of diſtillation with water; as has been practiſed here on tar purchaſed for that end; ſince, by this means, a very conſiderable quantity of the oil of turpentine would be obtained, even without requiring any ſubſequent rectifications.

EXPERIMENT XXXIX.

Separation of reſins from other vegetable ſubſtances, by means of vinous ſpirit.

Take the matter, containing the reſin; and, having reduced it to the ſtate of a groſs powder; or, if of a ligneous texture, to that of raſpings, or ſhavings; put it into a proper circulating veſſel; and add to it as much rectified ſpirit of wine, as will riſe two or three inches above it. Place then the veſſel in a gentle heat of ſand, or the balneum; and let it remain there for ſome time, ſhaking it at proper intervals. The reſin will, by this means, be diſſolved in the ſpirit; and ſeparated from the other vegetable matter: from which, being freed, by filtering the ſolution through linnen, it may be reduced to a drycohering ſtate, by evaporation in balneo, or by any other gentle heat.

OBSERVATION.

In this manner, thoſe reſins, which are ſoluble, may be extracted by vinous ſpirit from the root, bark, wood, or other parts of vegetables: and, may be either retained with ſuch ſpirit in the ſtate of a tincture; or ſeparated from it by the ſubſequent evaporation. This proceſs is frequently practiſed for medicinal views: but rarely for any others, unleſs in the caſe of experiments.

EXPERIMENT XL.

Separation of reſins from parts of vegetables, by means of the ſolution of alkaline ſalt.

Take the matter from whence the reſin is to be extracted; and, having reduced it to the ſtate of a powder,—or, if of a ligneous texture, to that of raſpings or ſhavings; put it into a ſolution of fixt or volatile alkaline ſalts: and let the mixture ſtand in a warm place for ſome days. The reſin will be diſſolved; and may be ſeparated from the ſolution, if of volatile alkaline ſalt, by evaporation only; but, if of fixt alkaline ſalt, departure alſo is neceſſary:

which

which may be thus made. Add to the ſolution, very gradually, diluted oil of vitriol, ſo long as any efferveſcence ſhall appear, on the addition of a freſh quantity: by which means the alkaline ſalt, being neutralized, the reſin will be departed and precipitated. The ſupernatant fluid muſt then be poured off as far as may be, without loſs of the reſin; and a freſh quantity of very clean water put to it: which muſt be ſeveral times repeated, to waſh away all the ſalts. The remaining fluid muſt be then ſeparated from the matter, by means of filtering through paper covered with linnen: and the reſin, being collected from the ſurface of the linnen, and put into a ſmall cup, may be dried in balneo; or by any other gentle heat.

In many caſes, reſins are not to be extracted from the other vegetable matter with which they are compounded, without the aid of heat; it is, therefore, neceſſary to boil them in a ſolution of lixiviate ſalt: and, in ſome inſtances, they even reſiſt all other ſaline menſtrua, but the ſolution of the ſal ſaponarius.

OBSERVATION.

By the means of ſolutions of alkaline ſalts, moſt of thoſe coloured reſins, which are not ſoluble in vinous ſpirit, may be ſeparated from the parts of vegetables: and not only all the other kinds, but even that, which ſerves as a gluten, to give firmneſs and rigidity to the conſtituent fibres of the ligneous parts of plants, may be extracted.

The firſt operation of this experiment is frequently practiſed for the purpoſes of dying, and making pigments for painting; and, in ſome few inſtances, for medicinal uſes: but the other is rarely performed, unleſs in an experimental view.

EXPERIMENT XLI.

Combination of reſins with ſubſtantial oils of vegetables.

Take any vegetable ſubſtantial oil; and, having put it into an earthen pipkin, or other proper veſſel, ſet it over the fire; where add to it gradually, as it grows hot, the reſin intended to be combined with it: which ſhould be previouſly powdered. Stir the mixture with a ſtick: and the reſin will be perfectly diſſolved.

OBSERVATION.

It is not, nevertheleſs, all reſins that can be thus diſſolved in ſubſtantial oils, though the terebinthinate reſins, gum lac, ſeveral of thoſe kinds that go under the name of the gums animi and copal, and many others, may.

This operation is frequently practiſed for the preparing drying oil for painting; for the compoſition of varniſhes; and, with the addition of wax, for forming the matter for covering oil and cere-cloth. It is ſometimes done, alſo, in the compoſition of plaſters and unguents, for chirurgical uſes: but rarely without the combination, alſo, of other ſubſtances.

EXPERIMENT XLII.

Combination of reſins with eſſential oils. See Experiment XVIII.

EXPERIMENT XLIII.

Combination of reſins with vinous ſpirit. See Experiment XXIX.

EXPERIMENT XLIV.

Combination of reſins with the ſolution of alkaline ſalts.

Take the reſin to be diſſolved; and, having groſsly powdered it, put it into to a ſolution of alkaline ſalt; and place it in a gentle heat for ſome time: or, in the kinds where that is not effectual, boil the mixture till the combination be made.

OBSERVATION.

The reſin, thus diſſolved, may be re-ſeparated from the ſolution of alkaline ſalts, in moſt inſtances, by the addition of any acid in the proportion that will duly neutralize the alkaline ſalt: or by the ſolution of alum, the earth of which being departed, will attract thoſe reſins, and precipitate them along with itſelf, that might, otherwiſe, remain combined with the ſolution of the neutral ſalt, formed by the alkaline ſalt and the alum.

The operation of this experiment is ſometimes practiſed on the reſin contained in woods, and other various vegetable matter, for dying, and the preparation of pigments; as, alſo, on ſome few occaſions, for medicinal uſes.

EXPERIMENT XLV.

Combination of reſins with the putrefying whites of eggs. See obſervation on Experiment XVIII. Sect. II. Chap. III. Part III. Vol. I.

EXPE-

EXPERIMENT XLVI.

Decompoſition of reſins by heat, on the principle of incaleſcence; exemplified in the caſe of the reſin of turpentine.

Take common reſin; and, having put it into a retort, diſtil it in a ſand bath; and an ethereal oil will be raiſed at firſt, of a more fluid conſiſtence, and yellow; and, afterwards, of a thicker conſiſtence, and reddiſh brown colour: a ſmall proportion of acid lymph riſing during the whole time. If the fire be gradually augmented, nearly the whole will come over, if the reſin be pure.

OBSERVATION.

All other reſins, being decompounded in the ſame manner, afford the ſame ſubſtances; but in different proportions: and many are not, like the common reſin, volatile, as to nearly the whole of their ſubſtance; but leave a larger proportion of coaly recrement.

This operation is never practiſed, but in experiments, unleſs for the ſeparation of eſſential oils from ſuch reſins, as have an aromatic, or other fragrant odour: or on Benjamin, for the ſeparation of the peculiar ſubſtance, called the flowers; of which there will be occaſion to treat more explicitly below.

EXPERIMENT XLVII.

Decompoſition of reſins by heat, on the principle of combuſtion.

Take reſin of any kind; and, having accended it, ſuffer it to burn with the acceſs of air: and if it be of the kinds allied to that obtained from turpentine, it will be diſſipated in flame, and vapour; leaving little or no aſhes: but there are other kinds, which containing a leſs proportion of ethereal oil, will not ſupport a burning ſtate, till they be diſſipated; but will leave a conſiderable recrement: which ſubjected to the action of exterior heat, the air being ſuffered to have acceſs, will leave ſome proportion of aſhes, or calcined earth.

OBSERVATION.

This operation is ſeldom practiſed, but on the compoſitions of common reſin, pitch, and others, in the form of flambeaus, or torches: or, in the compoſitions of frankincenſe, Benjamin, ſtyrax, and others, in the form of incenſe.

EXPERIMENT XLVIII.

Method of obtaining balſams from the trees which afford them.

Make inciſions in the depending parts of the bark of the turpentine tree, larch, pines, and other trees, affording balſams, and place a proper veſſel under them to receive the balſam, as it flows from the wounds. But the veſſel ſhould be of ſuch form, that the matter contained in it may be ſecured from the heat of the ſun, which would, otherwiſe, exhale the eſſential oil contained in the balſam, before a ſufficient quantity be collected.

OBSERVATION.

Many kinds of trees afford balſam without diviſion of the bark; and ſuch are collected from them But the quantity, ſo obtained, is ſmall: and if what thus exudes be not taken from the tree while freſh, it is ſoon inſpiſſated by exhalation; and loſes its proper balſamic conſiſtence. It is, therefore, by means ſimilar to thoſe directed in this experiment, that turpentine, as well the more valuable, as the common kind, are procured: though ſome of a coarſer kind, and more reſinous conſiſtence, are procured by heat in the manner deſcribed in the obſervations on Experiment XXXVIII.

EXPERIMENT XLIX.

Combination of native balſams with ſpirit of wine.

Take rectified ſpirit of wine; and add to it an eighth or tenth of its weight of the balſam to be combined with it. Set them, contained in a proper phial or bottle, in a ſand heat; and let them ſtand there for ſome time; frequently ſhaking them together. The balſam will be diſſolved; and form a tincture: which may be freed from the fæces, if there be any, by filtration.

OBSERVATION.

Some of the more fluid balſams may be inſtantaneouſly diſſolved in ſpirit of wine, by meer commixture without heat: but others, as the turpentines, can ſcarcely be perfectly diſſolved in it by any means; and require heat to effect that degree of combination, which may be made. This operation is ſometimes practiſed for the compoſition of ſome varniſhes, and for ſome medicinal preparations; but rarely without the ſuperaddition of reſins, or other ingredients, to the compoſition.

EXPERIMENT L.

Combination of native balſams with ethereal oils.

Proceed as in the foregoing experiment: only ſubſtituting the ethereal oil for the ſpirit of wine.

OBSERVATION.

This is frequently practiſed for the ſame end as the combinations of reſins with ethereal oils.

EXPERIMENT LI.

Combination of native balſams with ſubſtantial oils.

Proceed in the manner directed in Experiment XLI. for the combination of reſins with ſubſtantial oils: only ſubſtituting the balſam for the reſin.

OBSERVATION.

This is frequently practiſed for the compoſition of unguents, and plaſters, with the addition of other ingredients: and ſometimes, alſo, for the preparation of varniſhes.

EXPERIMENT LII.

Decompoſition of balſams by heat, on the principle of incaleſcence; exemplified in the inſtance of turpentine.

Take turpentine; and, having heated it in an earthen pot, till it be fluid, pour it into a retort: of which it may fill two thirds. Place the retort in a ſand bath; and, having luted to it a large receiver, diſtil with a gentle heat not exceeding 100 degrees, according to Farenheit's thermometer. When the diſtillation appears to grow languid in this degree of heat, raiſe the fire gradually, as occaſion may require; augmenting it, at length, to 212 degrees; or that point, at which water would boil; and when the fumes ceaſe to riſe, in any material quantity, with the continuation of this heat, let the fire extinguiſh. By this means, an ethereal oil, during the firſt degree of heat, perfectly limpid, thin, and colourleſs, but afterwards growing a little thicker, and verging towards yellow, will be obtained in the receiver; together with an acid lymph, in a conſiderable proportion: and in the retort will be found a recrement, which will be common reſin, that may be further decompounded by the means above directed in Experiments XLVI and XLVII. for the decompoſition of reſins.

OBSERVATION.

In like manner may be decompounded moſt other balſams: but the oils obtained will be in various proportions; as will alſo the ſcent, weight, and other qualities of them.

This decompoſition ſhews the conſtituence of balſams to be, eſſential oils, reſin, water, and acid: which are combined in a manner not to be affected by art. Reſins are always, therefore, a part of balſams; and are themſelves never produced but from balſams: unleſs thoſe kinds, which being combined with gums, are, by that medium, imperfectly diſſolved in water; as in the lacteous juice of plants.

This operation is conſtantly practiſed for the obtaining the oil of turpentine: but, at preſent, it is moſt generally performed in large ſtills with worms; water being added to the turpentine. It is, alſo, ſometimes practiſed in the ſame manner, and for the ſame end, on tar: which will afford conſiderable quantity of the like oil. The intention of the water is, to prevent the reſin, when the eſſential or native oil is raiſed, from being further decompounded

pounded by that heat which the part next the bottom of the veſſel would be ſubject to; and ſending over a thicker and coloured oil; which would deprave the other. But the reſin is, moreover, rendered leſs valuable, by part of it being diſcoloured by burning: and it is further ſaid, that the quantity of eſſential oil is, alſo, really increaſed, by this method, from ſome combination of the water with it: the collective weight of the oil produced, and reſin remaining after the diſtillation, being aſſerted to be conſiderably greater than that of the turpentine originally.

EXPERIMENT LIII.

Decompoſition of balſams by heat, on the principle of combuſtion.

Proceed as in the caſe of reſins, Experiments XLVII and XLVIII.

EXPERIMENT LIV.

Separation of gum-reſins from the lacteous juices of plants.

Evaporate the lacteous juices of plants, firſt over a fire, till the matter appear ſomewhat thick or viſcid; and then in balneo mariæ to dryneſs. The remaining maſs will be, in moſt inſtances, a gum-reſin: but, in order to diſtinguiſh when it is ſo, the decompoſition into the diſtinct gummous and reſinous ſubſtances may be practiſed.

OBSERVATION.

Gum-reſins are, likewiſe, to be obtained from the bark, root, or other parts of vegetables: from whence neither the lacteous ſap, nor any other juice is to be extracted: and, in this caſe, the whole being extracted by the uſe of ſuch menſtrua, as diſſolve the gums and reſins ſeparately, they may afterwards be combined by putting the extracts together; and evaporating the menſtrual fluid till the gum and reſin remain in a dry ſtate. But they are not, however, in many inſtances, to be united, by this, or any artificial means, as they are originally in the plant: and, therefore, where gum-reſins are naturally commixt with the other vegetable ſubſtances in a dry form, they are not to be ſeparated from them, ſo as to be obtained in their natural and intire ſtate.

This operation is practiſed on the lacteous juices of many plants, for the obtaining the gum-reſins in a dry ſtate; but moſtly with a view to the medicinal application of them: as in the caſe of opium and aloes.

EXPERIMENT LV.

Separation of gum-reſins from the ſolid parts of vegetables.

Take the ſolid parts of vegetables containing the gum-reſins; and, having reduced it to powder, if it conſiſt of the root or bark of any plant—or to that of raſpings, if it be ligneous, put it into a proper bottle or phial: and add as much rectified ſpirit of wine, as will riſe two or three inches above it. Set it in a gentle ſand heat, for ſome days, frequently ſhaking the veſſel, and a great part of the reſin will be diſſolved by the ſpirit of wine. Filter, then, this ſolution or tincture, through linnen: and then, having added to the reſiduum fifteen or twenty times its weight of water, boil the mixture for an hour or more, and the gummous part will be diſſolved by the water, as the reſinous was before by the gummous. Filter then the remaining fluid, while of a boiling heat, through flannel; and, afterwards, evaporate it over the fire till it begin to be of a thick conſiſtence;

ſiſtence: and then add to it the tincture, or ſolution made by ſpirit of wine, and finiſh the evaporation in balneo; reducing the matter, extracted by both the menſtrua, into one ſolid maſs; which will be the combined gum, and reſin, extracted from the vegetable ſubject.

OBSERVATION.

This operation is frequently practiſed for medicinal purpoſes on barks and roots: and the gum-reſin, ſo obtained, is called the *extract* of the vegetable matter from whence it is obtained: as in the inſtances of the Peruvian bark, and jalap root: however, it is not uſual, in ſuch caſe, to bring the matter to perfect dryneſs; but to leave yet ſo much fluid, as may render the extract of the conſiſtence of balſams: or, in ſome caſes, of paſte.

EXPERIMENT LVI.

Partial decompoſition of gum-reſins, by the reſeparation of the gummous and reſinous parts from each other.

Take any gum-reſins; and, having powdered it, digeſt it in rectified ſpirit of wine, for ſome days, with a gentle heat: after which, the veſſel being taken out of the heat, and, having ſtood at reſt ſome hours, decant off all the fluid that can be ſeparated in a clear ſtate, from the ſediment; and waſh the remainder with a little freſh ſpirit of wine. Evaporate the tincture obtained in balneo to dryneſs; and the reſiduum will be the reſinous part of the gum-reſin: as the ſediment, left by the tincture, is gummous: which, being freed from the greateſt part of the remaining ſpirit of wine added to waſh it, by filtering through linnen, it may be dried by laying it on any proper veſſel of glaſs, or China ware, before a common fire.

OBSERVATION.

This is, on ſome occaſions, practiſed for medicinal purpoſes: but, at preſent, not ſo frequently as it was formerly, in conſequence of a notion propagated by ſome eminent perſons, that the gummous part of thoſe gum-reſins, that were purgative, were much more lenient and ſafe than the reſinous; and, therefore, ought to be freed from it. But it is now moſt generally believed, on unprejudiced obſervation, that the gum-reſin, in its native ſtate, as in the plant, is more efficacious than, and equally ſafe with, any prepared extract.

EXPERIMENT LVII.

Decompoſition of gum-reſins by heat, on the principles either of incaleſcence or combuſtion.

See what is already delivered on the decompoſition of gums and reſins in the experiments relating to them; and compare them: for the effects in the decompoſition of gum-reſins by heat, in any manner, will be as the joint reſult of the decompoſition of any gum, and reſin, by the ſame means.

EXPERIMENT LVIII.

Purification of camphor from heterogeneous matter, by ſublimation.

Take camphor; and, having put it into a phial of a longiſh form, of which it muſt not fill above a third part, ſet in a gentle ſand heat; letting only a little more of the phial be buried in the ſand than is filled. The camphor will ſublime to the upper part of the glaſs: forming a tranſparent chryſtalline cake, of perfect whiteneſs; if the fire do not exceed the due degree,

gree, or the camphor itſelf be not depraved by the admixture of ſome coloured eſſential oil.

OBSERVATION.

The camphor, as found in the ſhops, is purified in a ſimilar manner to this; being brought from the Eaſt-Indies in a crude ſtate. The veſſels uſed in the ſublimation are a kind of ſhort conical bottles with flat bottoms and without necks. This kind is principally brought from China: and produced by the concretion of an eſſential oil, obtained by diſtillation of the wood of a peculiar kind of tree. But beſides this ſpecies, there is another produced in a native ſtate, in the iſlands of Barneo, Ceylon, and Sumatra: being found in cavities formed by nature, betwixt the bark and wood of the tree, under a chryſtalline appearance; and ſometimes attended with an eſſential oil, but at others not. The fair, bright, and larger pieces of this kind, are pickt out by the natives from the ſmaller and more impure; and ſold at a great price by thoſe who purchaſe it in order to its being ſent to China: where, though the other ſpecies abounds greatly, this is ſold, when perfect, at the rate of two or three guineas a pound. The value, which it bears in that country, is owing to its extraordinary quality of preventing animal ſubſtances from putrefying: on which ſcore it is employed for embalming the dead, according to the practice of perſons of condition; which it does in an effectual manner, by only ſurrounding the body with it, in the circoſſagus or coffin: ſuch body being firſt freed, in ſome degree, from the excrementitious parts, by pouring quickſilver into all the emunctories; and ſhaking and turning the body into all the different poſitions, that may aid the quickſilver, by its weight and fluidity, to expel the looſe contents of all the parts into which it can find acceſs. This kind is not imported here in the way of trade: bearing too great a price to be ſold in common with the kind brought from China for medicinal qualities; and not being wanted for the purpoſes of embalming: but it is highly probable the extraordinary qualities it poſſeſſes might render it uſeful in other reſpects.

Mr. Hellot, and ſome others, have prepared what they have called an artificial or imperfect camphor from the ethereal oil of ſpirit of wine: which is only, in fact, the concretion which happens in the oleum napthæ, produced as in Experiment XXXII. Sect. V. on keeping it for a long time: but as this ſubſtance wants the eſſential characteriſtic of camphor, of not being capable of being combined with either acid or alkaline bodies, in ſuch manner as to render it not again ſeparable from them in its intire ſtate; as, alſo, that of ſubliming wholly in a ſolid form, it ought not to be deemed camphor; but a ſulphureous concretion ſui generis.

EXPERIMENT LIX.

Combination of camphor with vinous ſpirit.

Take camphor; and, having powdered it, put it into a phial with ſpirit of wine; and, ſhaking them well together, the camphor will combine with the ſpirit; and be perfectly diſſolved.

OBSERVATION.

This combination may be again deſtroyed, by the addition of water; which will depart the camphor, and cauſe it to precipitate. On the principle of this ſolution and precipitation of camphor, a very eaſy method may be found of purifying it, where ſublimation cannot be practiſed: for the ſpirit of wine will ſeparate it from moſt kind of heterogeneous ſubſtances: and the water will again free it from the ſpirit of wine.

This combination is frequently made for medicinal uſes, as an embrocation.

EXPERIMENT LX.

Combination of camphor with ſubſtantial and eſſential oils of vegetables.

Take camphor; and grind it to powder in a glaſs or marble mortar: and then, adding to it either any ſubſtantial or eſſential oil, rub them well together with the peſtle. The camphor will, by this means, be diſſolved in the oil.

Or, otherwiſe, having powdered the camphor, put it, together with the oil, into a phial; and place it in a gentle heat; which may be moſt commodiouſly done by ſetting it in warm water, where let it ſtand, ſhaking it frequently, till the camphor be diſſolved.

OBSERVATION.

This combinatien is rarely practiſed, unleſs for experiments, to demonſtrate the ſoluble quality of camphor in ſuch oils: or, ſometimes in the preparation of luſory fire-works.

EXPERIMENT LXI.

Combination of camphor with mineral acids.

Take camphor; and, adding to it twice its weight of any of the mineral acids well freed from phlegm, treat it as the oil and camphor in the preceding experiment. The camphor will readily combine with part of the acid; and form a fluid, reſembling in its appearance ſubſtantial oils: which will float on the ſurface of the remaining acid: from whence it may be ſeparated by means of a proper tritorium.

OBSERVATION.

This combination of the camphor with the acids may be eaſily deſtroyed by the addition of water: which departs the camphor from the acid, in its original ſtate; the acid not having made any decompoſition of the camphor, as it would in all other inſtances of vegetable ſulphureous bodies, with which it could commenſtruate.

This combination is at preſent ſeldom practiſed; though it was formerly for medicinal purpoſes.

EXPERIMENT LXII.

Decompoſition of camphor by heat.

Take camphor; and ſetting fire to it by the touch of any body luminouſly hot, it will flame till the whole ſubſtance be conſumed; leaving no recrement or aſhes.

OBSERVATION.

Camphor can only be decompounded by heat on the principle of combuſtion: for being ſublimed, either in cloſe veſſels, or in the open air, it riſes in its whole intire ſubſtance. From its conſuming wholly in flame, as well as from its volatility and manner of production, its general affinity of nature with ethereal oils and ſpirits is manifeſted: but in theſe qualities of ſuffering no decompoſition, either by ſublimation, or combination, with acids, it varies ſpecifically from both; as it does, likewiſe, by not ſuffering the leaſt union with water, even by the intermediation of acids, alkaline ſalts, or any other ſubſtance hitherto known; which is, indeed, contrary to the nature of any other ſulphureous body whatever.

EXPERIMENT LXIII.

Separation of the flowers of Benjamin, from the reſin, by ſublimation.

Take Benjamin; and put it into a deep earthen pot, with a narrow rim or margin, turning off from its upper extremity. Fit a cap of paper, made by folding in a conical figure, to the upper part of the pot; and fix it there, by bringing it over, and then tying it round the pot under the rim. Place the pot then in a ſand bath; and ſublime with a very gentle heat, ſo long as the paper continues to be made warm. Take then the paper caſe from the pot; and it will be found covered on the inner ſurface with a white, or yellowiſh white, (if the heat was ſo ſtrong as to raiſe any of the oil) flaky ſubſtance, having a kind of chryſtalline appearance, which is the flowers of Benjamin.

If the quantity of Benjamin, put into the pot, be large, the paper ſhould be renewed during the operation: as the flowers, occupying a great ſpace, may, otherwiſe, not find room in the cavity of the firſt cap.

OBSERVATION.

This is practiſed for the obtaining the flowers of Benjamin for medicinal uſes: and the conducting it to the greateſt advantage is one of the moſt nice and difficult operations in the pharmaceutic chemiſtry. The greateſt art lies in adjuſting the heat, in ſuch manner as to raiſe the flowers without the oil: and in judging when to change the paper to prevent their falling down again into the pot. A thermometer ſhould, therefore, be uſed; and the operation performed in a wooden lamp furnace; where, by the extinction or reaccenſion of the ſeveral wicks of the lamp, the heat may be very quickly, either ſuppreſſed, or augmented, at pleaſure. If, after the utmoſt care, the flowers appear depraved with yellow oil, they may be purified by rectification conducted in the ſame manner as the original ſublimation; only taking care, to take off the cap of paper before the whole of the flowers be ſublimed: ſince the oil would again begin to riſe, and teint them as before. This rectification may, alſo be advantageouſly practiſed on thoſe flowers, which may be obtained by continuing the ſublimation, after the oil begins to riſe, ſo long as any will come over.

EXPERIMENT LXIV.

Separation of flowers of Benjamin from the reſin, by means of ſolution in water.

Take any quantity of Benjamin; and, having powdered it, put it into ten or fifteen times its weight of water already boiling, in a mattreſs. Let the mixture continue to boil for a ſhort time; and then take it out of the heat; and, pouring the whole into a ſmall receiver or other glaſs or earthen veſſel with a wide mouth, let it ſtand at reſt. When the water is grown cold, the flowers of Benjamin will be formed, in chryſtals of a needle-like figure, at the bottom of the veſſel, from whence they may be taken out.

OBSERVATION.

This operation is ſeldom performed, but for experiment; becauſe the ſublimation is equally eaſy to thoſe who know how to manage it rightly, and the quantity of flowers, to be obtained free of any impurity, is greater. It is, however, extremely curious: as it ſhews the ſaline nature of the flowers of Benjamin; which ſeems an extraordinary deviation of nature from the analogical ſyſtem, in forming a ſaline body of an eſſential oil, for ſo, with reſpect to its conſtituence, and all other qualities, except this, and its ſubliming in a ſolid form without any decompoſition, that ſubſtance muſt be eſteemed.

EXPERIMENT LXV.

Combination of flowers of Benjamin.

Proceed with vinous ſpirit as was directed for camphor in Experiment LIX; and the flowers of Benjamin will be diſſolved.

EXPERIMENT LXVI.

Decompoſition of flowers of Benjamin by heat, on the principle of combuſtion.

Set fire to the flowers, by putting a thick iron or braſs wire, heated red hot, among them; and they will be conſumed in flame.

OBSERVATION.

The flowers of Benjamin, when accended, will flame like eſſential oils: but they do not take fire ſo eaſily: the phlogiſton being more controlled by the acid in their conſtituence than in that of ſuch oils. It is, however, evident from this, as well as their volatility, that they are of a ſulphureous nature, according to the characteriſtics of ſulphureous bodies, given in the general obſervations on vegetable ſubſtances: but it is the only inſtance of any ſulphureous body, except ſpirits, and the ſalt ſaid to be formed by the concretion of oil of cinnamon, which may be juſtly ſuſpected to be of the ſame nature, that will combine with water, without the mediation of ſome third body.

For experiments and obſervations, relating to the nature of the ſaccharine matter, ſee p. 31.

EXPERIMENT LXVII.

Decompoſition of wax by heat, on the principle of incaleſcence.

Take wax; and, having cut it into thin pieces, put it into a retort, of which it may fill the half. Let the other part of the retort be then filled with clean ſand, almoſt up to the neck; and, afterwards, gently heated, that the wax may melt; and be commixt perfectly with the ſand. Place it then in a ſand heat; and having fitted on a receiver, diſtil with a gradual heat. An acid lymph of a diſagreeable ſmell will firſt come over in a ſmall quantity: which ceaſing to riſe, though the heat be continued of the ſame degree which firſt brought it over, let the receiver be changed for another fixt on with lute: and the fire being raiſed, an oil will riſe of a thin conſiſtence, as it condenſes on the ſurface of the receiver, but ſoon concreting to the thickneſs of butter, and of a colour almoſt white. The fire being ſtill more increaſed, the whole quantity of wax will come over; and form the ſame kind of butter; having loſt the hardneſs and friability of wax, and becoming unctuous; and liquifiable by the ſlighteſt heat; as other fat bodies of the ſame butter-like conſiſtence. This ſubſtance is, therefore, properly diſtinguiſhed by the name of the *butter of wax*. But it may be converted into a fluid, though very unctuous oil, by repeated diſtillations: which may be performed, by putting it into a retort without the addition of ſand, and having luted on a receiver, diſtilling by very ſlow degrees: of which the meaſure may be, that about ten drops fall from the neck of the receiver in one minute: till the whole be come over. By ſeveral ſucceſſive rectifications, performed in this manner, the oil may be rendered tranſparent, thin, and of a very ſoft relaxing nature. In this ſtate the produce of wax by diſtillation may be with propriety called the *oil of wax*; to diſtinguiſh it from the butter raiſed by the firſt diſtillation.

OBSERVATION.

The intention of uſing the ſand, in this diſtillation, is only to prevent the ebullition of the wax; which would be apt, otherwiſe, to make it overflow into the neck of the retort: for it does not combine with, nor change, in any other reſpects, the nature of the wax.

It appears from this experiment, that wax is greatly of the nature of ſubſtantial oils concreted: except with reſpect to its volatility, without further decompoſition, than the ſeparation of that acid and water, to which its greater concretion ſeems owing: and indeed the principal difference betwixt the butter or oil of wax, and ſubſtantial oils, conſiſts, in that the laſt have a greater proportion of earth than the other; as appears by the decompoſition by combuſtion: which accounts for this variation in the degree of volatility.

This proceſs is not applied to any other than medicinal purpoſes; and even with reſpect to them it is at preſent much neglected: though it is ſaid, that the butter, and in yet a greater degree the oil, is an excellent unguent againſt thoſe cracks of the lips, or hands, commonly called choppings; and in other caſes, where the emollient, and relaxing effects of oils are wanted.

EXPERIMENT LXVIII.

Decompoſition of wax by combuſtion.

Take wax; and ſubjecting it to a burning heat with the acceſs of air, it will conſume, as ſubſtantial oils, almoſt wholly in flame: leaving little or no earth or aſhes.

OBSERVATION.

The greater brightneſs of the flame of wax, its burning with much leſs ſmoke, and leaving no aſhes, evince, that there is a greater proportion of phlogiſton to the earth in wax, than in ſubſtantial oils: to which principle, alſo, its volatility without decompoſition is owing. It is for this reaſon, that wax is ſo far ſuperior to ſevous oils of animals, for making candles. The ſame proportionable difference is found, betwixt the groſſer and ſevous oil of animals, and the more fluid concreted artificially, as is now practiſed, into the fictitious ſperma cæti; where the oils being of a purer kind than that of tallow; and prevented from riſing too faſt in ſmoke, by the combination of acid, they approach, with reſpect to their combuſtive qualities, to the nature of wax.

EXPERIMENT LXIX.

Converſion of the yellow colour of wax into white, by the action of the ſun, and air.

Take wax; and having melted it in hot water, ſtrain it through a linnen cloth. When it is cold, cut it into very thin ſlices or ſhavings; and expoſe them, in ſome open place ſecured from duſt, to the ſun and air, often turning them; and ſprinkling them with clean water. In ſome time, variable according to the ſeaſon and weather, the whole ſubſtance of the wax will become perfectly white; and much more brittle than at firſt: and will burn with leſs ſmoke; leaving little or no aſhes. The wax in this ſtate is called *white* or *bleached wax.*

OBSERVATION.

This change can only be made on the brown wax forming the combs of bees: for the green colour of the wax, obtained from the candle-bury myrtle, is not to be diſcharged from it, without the decompoſition of the wax, by any means hitherto known: though the diſcovery of ſuch means, which ſeem very poſſible, might be very conſiderable to ſome of our colonies. Mr. Boyle aſſerts, that brown wax may be rendered white by melting it, through means of heat, in ſpirit of wine: but it is one of thoſe many extraordinary miſtakes, into which he has fallen with reſpect to facts of this kind; for no ſuch effect follows, in any degree, that operation.

This proceſs is practiſed in the way of a common manufacture, for preparing wax for making candles, and for other purpoſes; and it is called the *bleaching wax:* ſome other method of effecting which, in a much quicker and leſs laborious manner, might probably be diſcovered, if the proper experiments were judiciouſly and induſtriouſly made.

EXPERIMENT LXX.

Separation of the colorific matter of the ſtamina, and petals, of the flowers of various plants; exemplified in the inſtance of ſaffron.

Take ſaffron; and, having put it in a proper phial, pour on it rectified ſpirit of wine; till it riſe three or four inches above the ſurface, and ſet in a gentle heat, for three or four days, frequently ſhaking the phial. Remove it then from the heat; and let it be a day at reſt, and afterwards ſtrain off the tincture or ſolution, that will be formed, through linnen. To the remaining ſaffron, add the ſame quantity of ſpirit of wine as before; and repeat the ſame treatment in other reſpects; only, inſtead of a ſecond repetition of the ſpirit of wine, ſubſtitute water. Shake the ſaffron well in the water; and then, ſuffering it to ſubſide, ſtrain off the coloured fluid; and add a ſecond quantity of the water, which may be alſo ſhaken and ſtrained off as the other. Mix then together all the quantities of the ſpirituous tinctures, and coloured water: and evaporate them, over a gentle fire, till the fluid appear to acquire ſome degree of thickneſs; after which proceed with a very gentle heat, to bring the matter to a ſolid conſiſtence in balneo; obſerving, nevertheleſs, not to urge it to too great dryneſs; as even moderate heat will affect it, after it is freed from all moiſture.

OBSERVATION.

This extract is called the *eſſence* of ſaffron; and may be made with water, inſtead of ſpirit of wine: but a greater heat is then neceſſary to ſeparate the whole of the colorific matter from the fibrous part of the chives. Since the attraction of ſpirit of wine is greater to ſuch matter than that of water, even aided by alkaline ſalt; as may be ſeen in the following experiment. Take ſome portion of lixiviate ſalt, and a few chives of ſaffron; and add to them ſome water; but not in a proportion to diſſolve the whole of the ſalt. After the mixture has ſtood ſome time, put to it two or three times the meaſure of the water of pure alcohol, prepared by means of lixiviate ſalt, as directed in Experiment XXVII. Sect. V. and, having ſhaken them together, the alcohol will take the colour, from the ſolution of the ſalt; leaving it colourleſs. Or, in default of alcohol already prepared, take two or three chives of ſaffron, and, having tied them to a bit of iron wire, that they may be kept by its weight at the bottom, put them into a phial; and add to them common rectified ſpirit of wine; and in a ſhort time yellow lines will dart from the bottom to the top, and there collecting form a coloured body; which will extend itſelf gradually downwards till it reaches the ſolution of alkaline ſalt; and there bound itſelf: the ſolution remaining uncoloured, under the tinged ſpirit. The ſame would happen, ſhould the ſpirit of wine and water be put together ſimply; if they would remain in a ſeparate ſtate from each other: but they neceſſarily unite; as, when the water is not impregnated with lixiviate ſalt, it is requiſite to the end of the experiment to add it.

The ſame operation may be practiſed on the colorific matter of the petals of the flowers of many other plants; from whence a matter of the ſame general nature will be obtained; though differing in ſcent, colour, and flavour, and in ſome inſtances combining with vinous ſpirit and rejecting water; in others, with water rejecting the vinous ſpirit; or with both, as the ſaffron. In extracting this matter from the fibrous part of any vegetable matter affording it, regard muſt, therefore, be had to the particular nature of the vegetable in this reſpect. This operation, as far as regards the ſolution and part of the evaporation, is practiſed on ſaffron, for the making the medicinal extract, called the *eſſence* of ſaffron; and by ſome after Paracelſus, the *aroph*, as meaning the *aroma philoſophorum:* which is not, however, to be brought to a dry ſtate, but ſuffered to retain ſuch a quantity of the fluid, that the eſſence obtained may equal the weight of the ſaffron from whence it was obtained. It is, alſo, practiſed, ſo far as the ſolution, on violets, clove jelly flowers, and others, for the compoſition of medicinal ſyrups: and ſometimes, alſo, for making pigments, and tinctures, for painting, and ſtaining.

EXPERIMENT LXXI.

Combination of the colorific matter, as obtained in the preceding experiment, with water.

Take the extract, as obtained in the preceding experiment; and, putting it into a phial, add warm water; and, ſhaking the phial, the coloured matter will be perfectly diſſolved by the water; forming a tranſparent ſolution.

OBSERVATION.

The ſame may be done by all other ſimilar extracts, but thoſe which are ſoluble in ſpirit of wine only. It is rarely practiſed to diſſolve the ſeparated matter of this kind: becauſe the ſame ſolutiom may be made by uſing the part of the vegetable affording it: which is conſequently done on many occaſions for making coloured tinctures.

EXPERIMENT LXXII.

Combination of the colorific matter, as obtained in Experiment LXX, *with vegetable oils.*

Take any kind of vegetable oil; and, having put it into a phial, add to it the extract or eſſence of ſaffron, as procured by Experiment LXX. Place the phial in a moderate heat; and let it remain there, ſhaking the veſſel at proper intervals, till the extract be diſſolved in the oil.

OBSERVATION.

The combination with oils, is peculiar to the colorific matter of the ſaffron; and ſome few other ſpecies; and not general to this kind of ſubſtance. It is not at preſent practiſed, unleſs

leſs in the caſe of one peculiar kind, which varies from moſt others in rejecting combination with both vinous ſpirit, and water, unleſs in an imperfect degree; though it readily and perfectly combines with oils. This is the tinging matter of the alkanet root: which, on the ſcore of this quality, is employed in the compoſitions for lip-ſalves, and ſome other purpoſes, where the giving a red colour either to fluid, or ſevous oils, may be required.

EXPERIMENT LXXIII.

Decompoſition of the colorific matter, as obtained by Experiment LXX. *through heat, on the principle of incaleſcence.*

Take the extract, as obtained by Experiment LXX. and, putting it into a retort, diſtil with a gradual heat: and an ethereal oil, with a lymph ſlightly acid, will come over.

OBSERVATION.

This proceſs, not producing any ſubſtance of value equivalent to the expence of the preparation, has never been practiſed; unleſs as an experiment, to ſhew the conſtituence of the ſubject matter.

SECTION VI.

Experiments and obſervations on the native acids of vegetables.

EXPERIMENT I.

Combination of the native vegetable acids with alkaline bodies.

TAKE any native acid of vegetables; ſuch as that afforded by lemons, oranges, or any other fruit of a ſour flavour; and, having diluted it with an equal quantity of water, add to it, gradually, any alkaline ſalt, or earth, ſo long as any effervesſcence ſhall appear to follow on the further admixture. Filter then the ſolution; and, afterwards, evaporate it in balneo; and a neutral ſalt will be formed; but different according to the different kinds of acids.

OBSERVATION.

As the ſalts, produced thus, will be different when formed by the acids of different vegetables, though with the ſame alkaline body; ſo they will be, alſo, different from what they would be, if vinegar was ſubſtituted in the place of them. This difference may be evidently diſcerned in the caſe of lixiviate ſalt combined with the juice of lemons, and with vinegar: for, with the vinegar, the ſal diureticus, or the terra foliata tartari, will be produced; which will be found to diſſolve readily in ſpirit of wine, to aſſume, under proper management, a peculiar foliated appearance, and to poſſeſs other properties wanting in the ſalt formed by the juice of lemons. In trying this experiment with a great number of alkaline bodies, as alſo with the colorific matter of vegetables, this kind of acid will be found a more general menſtruum than vinegar, or any other ſpecies; and may, therefore, be applied, with great advantage, to the taking out the ſtains, called iron molds, formed by ink; or other ſtains made by metallic bodies; and to cleanſe ſubſtances, when fouled by adheſions of any alkaline matter; or vegetable tinges on their ſurface.

This proceſs is frequently practiſed in medicine, ſo far as the combination of the two ſubſtances, in the inſtance of lixiviate ſalt, under the names of ſalt of wormwood, or ſalt of tartar, for the compoſition of the *hauſtus febrifugus*, as it is called: the efficacious part of which is, in fact, nothing but the ſolution of the neutral ſalt generated by the combination of theſe two ſubſtances; though diſtilled waters or ſpirits, or other ingredients, be added for the parade of the form.

INSTITUTES

OF

Experimental Chemiſtry.

PART V.

Experiments, and obſervations, on metallic bodies.

CHAP. I.

General obſervations on metallic bodies.

METALLIC BODIES are opake, ſhineing, ſubſtances; of foſſile production. Their generical characteriſtics conſiſt, *in the being heavier than any other bodies;—inſoluble in water, without addition;—fuſible, as to their whole ſubſtance by heat, at leaſt under ſome circumſtances of combination with each other; or otherwiſe fluid in every degree of heat, and cold;—and indecompoundible by heat, on the principle of incaleſcence (that is to ſay, with the abſence of air and nitre):* which qualities, with *a peculiar ſhining, or glittering appearance, and that of a ſtriated, or laminated,*

nated, texture in parts broken from each other, when taken together, diſtinguiſh metallic from all other bodies.

In their *opacity*, and *ſtriated or laminated texture, and peculiar glittering appearance*, metallic bodies differ from glaſs, formed or compounded, either wholly, or in part, of themſelves; and in their *inſolubility in water*, from ſalts compounded, in part, of themſelves; both which reſemble them in their ponderoſity:—in their *not admitting of decompoſition by heat on the principle of incaleſcence*, they differ from the ores that are compounded of themſelves and mineral ſulphur; which reſemble them in their ponderoſity and glittering appearance:—and in their *greater ſpecific gravity, and peculiar ſhining or glittering appearance*, they differ from all other ſubſtances.

Metallic bodies appear, either poſitively, or analogically from the analyſis and reſuſcitation of the greateſt number of them, to be conſtituted of an earth peculiar to each kind, and phlogiſton: but this is not experimentally demonſtrable with reſpect to gold, ſilver, mercury, and platina: as they ſuffer no analyzation, or decompoſition, by which their elements can be ſeparated ſo as to ſhew the ſimple nature of them: nor can there, conſequently, be any opportunity of ſuch a reſuſcitation, as would evince what were the proper elements, from the actual re-production of the compound. It is, however, reaſonable, from analogy, to conclude, that theſe four metallic bodies, as they agree in all other general properties with them, are formed of the ſame conſtituents as the others: and, indeed, ſome properties of gold leave no room to doubt, but that it contains an equal, if not much greater, proportion of phlogiſton, than other metalline bodies; and that, beſides ſuch phlogiſton, it is formed of ſome earthy baſis, is evident from its qualities: as phlogiſton neceſſarily requires ſuch a medium, in order to its conſolidation and fixity. The other metallic bodies, except gold, ſilver, platina, and mercury, admit, however, of an analyzation; and put this point out of queſtion with regard to them: for, by combuſtion either with the acceſs of air, or by the addition of nitrous ſalts in a due degree of heat, they are calcined; that is, the phlogiſton is ſeparated from them, by its combination with the ſpirit of nitre in the air, or the nitrous ſalts; and the earth left in a ſimple ſtate; or ſuch an approximation to it, as is the ſame with reſpect to all ſenſible effects. The qualities of theſe earths, while in their ſimple ſtate, have been before illuſtrated in the obſervations and experiments on earths, already given: and the more particular nature of each, with reſpect to union with, or ſeparation from, the phlogiſton, will be diſplayed in the following experiments on metals.

Metallic bodies are generally diſtinguiſhed into METALS, and SEMI-METALS: and to theſe may be added, a third claſs; formed of ſuch, as differing both from metals and ſemi-metals, in ſome other particuticulars, though they agree with them, in thoſe which I have given as the ſpecific characteriſtics of metallic bodies, and vary, of courſe, generically from all other ſubſtances, may, therefore, be deemed ANOMALOUS, or HETEROCLITE METALLIC BODIES. The metals are ſix in number; GOLD, SILVER, COPPER, LEAD, TIN, and IRON:—the ſemi-metals are commonly eſteemed four in number; ZINC, BISMUTH, REGULUS OF ANTIMONY, and ARSENIC in its reguline ſtate; but to theſe, ſome have more lately added two others, under the names of *regulus of cobalt* and *nickel*:—the anomalous or heteroclite metallic bodies, at preſent known, are two; *platina*, and *mercury*.

Metals are, metallic bodies poſſeſſing the qualities, above aſcribed to ſuch in general; but differing from all the others, *in being more malleable under proper circumſtances*; as, alſo, from all, but platina, in their *greater fixity*; from the ſemi-metals, in their *greater ſpecific gravity*; from platina, in their *fuſibility*; and from mercury, in their *ſolid conſiſtence*;—and from all other ſubſtances, in that *combination* of qualities, *which gives the ſpecification to metallic bodies.*

Malleability, in an abſolute ſenſe, is, by moſt writers, inaccurately made the characteriſtic or mark of ſpecification betwixt the metals and other metallic bodies; but it is not juſtly authoriſed by the fact. For platina, and ſome of the ſemi-metals, when pure, have a ſenſible degree of this quality: and the metals themſelves may be deprived of it, without any other ſenſible change in their nature; as, indeed, in its native ſtate, one of them is almoſt conſtantly devoid of it; and owes it, in almoſt all caſes, to a change produced by art; and yet, under the privation of this quality, none ever ſcrupled to deem them metals. If, therefore, this quality be not peculiar to metals, but in the degree, and they may juſtly exiſt without it, under that name, it ought not to be ſaid, that they differ from other metallic bodies in being malleable; but only, in having the power or capacity of becoming ſo in a greater degree than they. As the other expreſſion ſeems to imply, that metals are always malleable, and other metallic bodies never ſo; which is certainly contrary to the true ſtate of the matter. Since platina, and zinc, are far from totally wanting this quality: and iron, in its natural ſtate, very rarely poſſeſſes it; and, having attained it through changes produced by art, may be deprived of it by the ſlighteſt means; and ſuch as cannot be alledged, on any demonſtrable ground, either to add any thing to, or take away from, its proper conſtituence: and the ſame holds good, in ſome manner, of all the other metals.

Metals are divided into two claſſes; the PERFECT, and IMPERFECT: by the *perfect*, is meant ſuch as are ſo conſtituted, as to ſuffer no decompoſition or change by culinary fire: reſiſting, in a fixt ſtate, the greateſt heat, of that kind, for any length of time: and by the *imperfect*, thoſe which become volatile, and are alſo analyzed by heat: ſubliming either wholly, or ſuffering the phlogiſton to exhale, and leave the earthy part, or baſis, either in the form of a calx, or ſcoria.

The *perfect* metals are two in number; GOLD and SILVER; the *imperfect* metals are four; COPPER, TIN, LEAD, and IRON.

Gold has the firſt place given to it of the two perfect metals. It poſſeſſes all the characteriſtic qualities of metals above enumerated in a plenary degree; and joins to them a ſpecific gravity, greater than that of any metallic or other body hitherto known; (unleſs it ſhould prove, as ſeems very probable, when platina ſhall be reduced to a purer ſtate, than when made the ſubject of examination in the experiments hitherto publiſhed, that it is an exception to this poſition;) being betwixt nineteen and twenty times as heavy as water, which appears by the proportion it loſes when weighed in that medium. It is of a full yellow colour; and is liquified by the degree of heat, which brings it to a ſtate of luminous whiteneſs; but it, nevertheleſs, remains without change in that, or any other degree of heat producible by culinary fire, for the greateſt length of time in which it has been hitherto continued in ſuch a ſtate. For, though Mr. Homberg has aſſerted, that in the experiments tried by him on gold, it was vitrified, and rendered volatile, through a focal heat collected by means of a very large concave mirror; yet, from the failure of all others in effecting the like, either by the ſame, or even larger glaſſes, the veracity of his relation, or the accuracy of the encheireſis of his experiment, may be juſtly doubted: and it may be received, on good grounds, that gold, in its ſimple ſtate, is neither to be rendered volatile, nor changed in its form or qualities, otherwiſe than what relates to fuſion, by any degree of heat whatever producible by art. Gold is the moſt malleable of all metallic bodies, when in a pure ſtate; and, under due circumſtances of temper (according to what will be hereafter explained of that principle), is very flexible: on account of which ſoftneſs of texture, it does not afford, when ſtruck, a tinkling bell-like ſound, as the more rigid metallic bodies. It combines freely, when in an intire ſtate, with a compound of the acid of ſea ſalt and nitre, called, for that reaſon, *aqua regia*; and is perfectly diſſoluble by it: but not in the leaſt with either the vitriolic, or nitrous ſimply, in any ſtate. There are, nevertheleſs, ſome who affirm, that the magiſtery, precipitated from the aqua regia, is ſoluble in ſpirit of ſalt; and with ſome truth, if no ablution be made of the ſalts from the magiſtery: for this does not contradict the doctrine, that gold will combine with no acids except a compound of thoſe of nitre and ſea ſalt; as a conſiderable proportion of the nitrous acid of the aqua regia, from whence the precipitation was made, remains combined with the gold, in the precipitated ſtate; and co-operates, with the freſh ſpirit of ſalt added, in the re-diſſolution of the magiſtery. It is ſaid, likewiſe, that the ſpiritus ſalis dulcis, or combination of the ſpirit of ſalt with vinous ſpirit, effects this ſolution more powerfully than the ſimple acid of ſea ſalt. Gold, being in a diſſolved ſtate, by means of aqua regia, will combine freely with the æther, or exalted oil extracted from vinous ſpirit by the decompounding power of the vitriolic acid; ſuch æther departing the gold from the aqua regia, and keeping it in a boyant ſtate, on the acid.

It is, likewiſe, departed from aqua regia by the addition of alcohol or eſſential oils; and, for ſome ſmall time, ſuſpended on the ſurface of the fluid by them; but, at length, precipitates: from whence it may be reaſonably concluded, that this departure is made rather by a combination of the alcohol, or eſſential oil, with the acid, rendering it neutral to the gold, than by their attractive action on the gold itſelf: though the conſequence of retaining the gold ſhews it to be otherwiſe in the caſe of the æther. The gold may, alſo, be departed from aqua regia by all the metallic bodies, except ſilver and arſenic; as, likewiſe, by alkaline ſalts and earths; a precipitation following, in all theſe caſes. The magiſtery, obtained by the precipitating it through the means of alkaline ſalts, being expoſed to a moderate heat, explodes with an immenſe force: a very ſmall quantity giving the report of a piſtol or muſket; from whence the magiſtery of gold, in this ſtate, is called *aurum fulminans.* A feather, or any other animal or vegetable ſubſtance, being dipt in the ſolution of gold in aqua regia, will be ſtained by it of a red colour: which is a property not found in the ſolution of any other metallic body.

Gold will alſo combine with hepar ſulphuris, by commixture with it, in the fuſed ſtate of the hepar: and, the compound produced, will ſo combine with water, as to be perfectly diſſolved by it. It may be alſo diſſolved, when in the ſtate of a magiſtery, in a ſolution of the lixiviate ſalt, previouſly combined with the fixt ſulphur exiſting in the coal of animal ſubſtances.

From both theſe laſt mentioned menſtrua, the gold may be departed by the addition of any acid: or, otherwiſe, ſeparated from them by decompoſition, through heat on the principle of combuſtion, of the ſulphur; as it will be, by that means, deſtroyed, or ſublimed; leaving the gold and lixiviate ſalts.

The magiſtery of gold is, likewiſe, ſaid to be ſoluble in a ſolution of volatile alkaline ſalts: but to ſucceed in this, a thorough ablution of the ſalts ſhould be previouſly made from the magiſtery.

The magiſtery of gold being mixed with vitreous fluxes, or even with moſt kinds of glaſs, it will vitrify, if that degree of heat, which will liquefy ſuch fluxes or glaſs, be adminiſtered, and duly continued. This glaſs, when the magiſtery is precipitated from the aqua regia, by tin or other metallic bodies under due circumſtances, will be of a red colour, like that of a ruby: but when produced by precipitation, made with alkaline ſalts copiouſly uſed, it will incline more to a purple. Gold may be again brought back from this vitreous, to its original metallic form, by the reduction or decompoſition of the glaſs; and ſubſequent fuſion with alkaline ſalts.

The malleability of gold may be leſſened or increaſed, through the alteration of its temper, by heating it to near a luminous degree, and immerſing it in ſome cold medium, or ſuffering it to cool gradually: but it may be, in a much greater degree, deprived of this quality, by the fumes of vegetable ſubſtances burning, and not reduced to the ſtate of a perfect coal; or by the admixture of arſenic, even by cementation, and of the other ſemi metals or tin; and, alſo, in various leſs proportions, by lead, iron, copper, or platina. The yellow colour of gold is, likewiſe, impaired by the fumes of arſenic, or admixture of tin; as, likewiſe, by lead, in a very great degree; and the other metals in various leſs proportions. The ſame effect is produced by fuſion together with nitre or borax: but may be again removed by a fuſion with ſea ſalt: or by cementation with other bodies containing the acid of that ſalt; and made to emit it in the ſtate of fumes.

Gold, therefore, differs from ſilver, *in its being of a yellow colour*, and *having a greater ſpe-*

ſpecific gravity; and *in reſiſting*, when in an *intire ſtate*, the *diſſolving* or *corroding action of all acids, except aqua regia*; and *the volatilizing action of antimony*; as, alſo, *in refuſing all combination with mineral ſulphur*:—from all other metallic bodies, likewiſe, (except perhaps platina,) *in having a greater ſpecific gravity*, and thoſe *qualities that are peculiar to perfect metals*:—from platina, *in its colour*; *fuſibility*, without *addition, by the heat of culinary fire*; *intire precipitation from aqua regia*, by the *addition of metallic*, or *other alkaline bodies ſingly*; and *tinging glaſs of a red colour*:—and from all other ſubſtances, *in having the qualities peculiar to metallic bodies*.

Gold is frequently found in a native ſtate; moſt commonly in the form of duſt; but ſometimes in larger maſſes; in which caſe it is called *virgin* gold. It is, however, rarely or never pure, in its foſſile condition; but combined with either a greater or leſs proportion of ſilver. There is no proper ore of gold: but it is generally commixt with various kinds of ſtones, ſand, or earth; particularly the kinds of flints called *quarzt*; and the *lapis lazuli*; as, alſo, with the ores of copper and ſilver. Gold is ſeparated from the ſtones, ſand, or earths, with which it is commixt, by elutriation, and amalgamation with mercury; and from them, and other metallic bodies, (except ſilver,) or their ores, by uſtulation; ſcorification with lead, and ſubſequent precipitation by gravity, and cupellation;

by detonation with nitre; and by cementation;—from ſilver by ſolution in aqua regia; and ſubſequent precipitation by departure; as alſo from that, or any other metallic bodies, by precipitation through gravity, and repurgation, by means of crude antimony;—and from glaſs by the reduction or decompoſition of it.

SILVER, which is the other of the perfect metals, poſſeſſes, likewiſe, all the qualities which are above made the characteriſtic of them; to which is joined, a white colour ſomewhat milky. It is eleven times as heavy as water, and, conſequently, of greater ſpecific gravity than any other known body, except gold, mercury, and platina: and it is fuſed by leſs heat than gold; but, like that metal, it remains unchanged under the action of any fire to be produced by art (unleſs confidence be placed in the experiments of Mr. Homberg, which, for the reaſon before given, may be juſtly ſuſpected). Its malleability approaches the neareſt to that of gold, but is yet inferior. It is perfectly ſoluble in the acid of nitre, that is pure with reſpect to all other bodies, and is not commixt with more than a certain proportion of water; but it may be departed from this acid, by the bodies before enumerated that will precipitate gold from aqua regia. It combines, likewiſe, with ſimple oil of vitriol concentrated, and in a boiling ſtate: and, alſo, with that acid, and ſpirit of ſalt, likewiſe, without heat, when it is previouſly diſſolved in ſpirit of nitre: but a precipitation is, in this caſe, always the reſult. When this precipitation is made with ſpirit of ſea ſalt, the new compound being formed of ſome proportion, as well of the acid of nitre, as of ſea ſalt, is called *luna cornea*: for, being fuſed, it aſſumes a ſemi-tranſparent appearance, in ſome degree. The ſolution of ſilver in ſpirit of nitre, tinges feathers, hair, or other animal ſubſtances, of a black colour: which is a property peculiar to it. Silver is ſaid to ſuffer, likewiſe, a combination with vinegar, and the native acids of vegetables, ſuch as the juice of lemons; being previouſly reduced to the ſtate of a magiſtery, by ſolution in ſpirit of nitre and ſubſequent precipitation. It is departed, as gold, from any acid, by the means of the addition of any metallic or other alkaline body, except gold, which will commenſtruate with the reſpective acids. It combines with mineral ſulphur in a luminous degree of heat; and, like gold, with hepar ſulphuris; or with the lixivium prepared from lixiviate ſalt, and the fixt ſulphur of animal coal: the ſame conſequences, reſulting with reſpect to its departure or ſeparation from theſe bodies. The magiſtery of ſilver being commixt with vitreous fluxes, or with glaſs, is vitrified in a proper degree of heat; aſſuming a yellow colour; and it may be recovered from this ſtate by the means above mentioned with relation to gold.

Silver combines with gold: and with all the other metallic bodies; but they take away, nevertheleſs, its malleability in various reſpective degrees; particularly tin, and arſenic, of which even the fumes have this effect in a very extraordinary manner. Its commenſtruation with lead is not, however, ſo ſtrong, but that a ſeparation is made by the difference of their ſpecific gravity, if they be kept in a quiet ſtate in fuſion for ſome time.

Silver, therefore, differs from gold, *in its being of a white colour*; and *having a leſs ſpecific gravity*:—from all other metallic bodies, except gold, and platina, *in its fixity*; the quality peculiar to perfect metals:—from platina, *in its leſs ſpecific gravity*; and *in its fuſibility with the heat of culinary fire without addition*:—and from all other ſubſtances, *in having that combination of qualities, which makes the proper characteriſtic of metallic bodies.*

Silver is found, indeed more frequently than any other metal, in a native ſtate, under a filamentous, or ſcaly, form, commixt ſometimes with various ſtones, and earths; but for the moſt part, with ſand. It is, alſo, found in the ſtate of a proper ore, in various ſpecies: the principal of which are diſtinguiſhed by the names of, the vitreous, corneous, red, and white; beſides others, at preſent not known by particular names; all which are combinations of the ſilver with mineral ſulphur, arſenic, iron, copper, and ſometimes lapidaceous earths. It is, likewiſe, obtained from the ores of other metals; particularly from the white, and grey ores of copper; and frequently from thoſe of lead; as well as from the metal itſelf.

Silver is ſeparated from the other metallic bodies, ſtones, earths, ores, &c. by the ſame means, as above enumerated, in the caſe of gold; and from gold, by ſolution in aqua fortis, and a ſubſequent precipitation by departure.

COPPER is the firſt of the imperfect metals; and has all the characteriſtics above given them. It is of a yellow colour, varying towards a red; betwixt ſeven and eight times as heavy as water; and malleable in the next degree to gold and ſilver. It commenſtruates with all acids; but requires a boiling heat to its ſolution in pure oil of vitriol: and being combined with it, a blue ſalt is produced; but with the other acids, the ſolution, or ſalts, appear green. It is diſſolved alſo by ſolution of alkaline ſalts; and combines with ſulphur, hepar ſulphuris, and rancid oils of animals, or vegetables. It combines, likewiſe, with all the metallic bodies, except mercury, with which, while in an intire ſtate, it will not perfectly unite: but it is ſaid, that an amalgamation may be made of it in the ſtate of a magiſtery; though in many repeated trials, I have known made, a failure of effecting it enſued. It requires the heat of a fire luminouſly white to fuſe it; but being kept in fuſion, with the free acceſs of air, it is calcined gradually; loſing a part of the phlogiſton to which it owes its metallic form; and being converted, either to the ſtate of a calx, or to a ſcoria.

This calcination is accelerated, or retarded, according to the proportion of the ſurface of the maſs of metal; and may be inſtantaneouſly effected by the addition of nitre, even though the air be excluded; which, by the combuſtive action produced, deprives the metal of the phlogiſton. The metallic form may, however, be again given to the calx of copper, by reſtoring the phlogiſton, through the means of ſubjecting ſuch calx, commixt with the coal of any animal or vegetable ſubſtance, in a cloſe veſſel, to the degree of heat that will fuſe the copper. This operation is called *reduction*: and is more difficultly practiſed on copper than on lead or tin. Copper being commixt with vitreous fluxes, or glaſs, is converted alſo to glaſs of a green colour. The temper of copper may be varied, by the manner of cooling it, after it has been made hot: and its tenacity may be likewiſe increaſed by hammering when cold.

Copper differs from gold, and ſilver, *in wanting the peculiar qualities of perfect metals*, which they have:—from other metallic bodies, *in being of a reddiſh yellow, or orange colour; and in its ſpecific gravity*:—and from all other ſubſtances, *in having the combination of qualities peculiar to metals.*

Copper is frequently found in a native ſtate; but not intirely pure: as its want of malleability, in ſuch ſtate, ſhews: it is alſo obtained from a variety of ores; which are not to be known by any particular figure; but they may, in moſt caſes, be diſtinguiſhed by their blue, purple, or green

colour;

colour; though, in ſome very few inſtances, copper ores are found of a red colour, and diaphanous. The proper ores of copper already noted are called, the vitreous; lazureous, or blue; green; mountain blue; mountain green, otherwiſe improperly called chyſocolla; white; yellow, or brick coloured; and the cuprous pyrites: the yellow ferreous pyrites, likewiſe, affords copper, though from its exceſs in the proportion of iron to the copper, it is not properly an ore of copper, but of iron. Theſe ſeveral ores are combinations of copper with ſulphur, arſenic, lapidaceous earth, and always iron, generally in a moſt copious manner.

Copper may be ſeparated from the iron, ſulphur, earth, ſtones, &c. with which it is commixt, by elutriation, reduction, and colliquation;—from gold, by ſolution in aqua fortis;—and alſo from ſilver, by ſolution in aqua regia, or by eliqualition with lead.

LEAD has the metallic characteriſtics above enumerated; and is of a greyiſh white colour, and betwixt eleven and twelve times as heavy as water. It is leſs malleable than copper, but more than tin: and is more yielding and ſoft than any other metallic body. It is fuſible in leſs heat than will render it luminous; but it reſiſts the calcining power of heat much leſs than copper or iron, though more than tin: for being kept in fuſion, and the air ſuffered to have acceſs, it is converted to a yellowiſh brown pulverine ſubſtance; which by longer calcination becomes of an orange red; and it is then called *minium*, or *red lead*; but being urged with a greater degree of fire, it either vitrifies, and forms a ſcoria which is called *litharge*; or, by a yet ſtronger heat, is converted into a yellow glaſs. The lead thus varied, by heat, from its metallic form, does not, however, become a perfect calx; or, in other words, is not rendered devoid of phlogiſton diſcoverable on experimental examination: for, on the addition of nitre to it, when it is heated to a luminous degree, it detonates ſtrongly; which evidently indicates the preſence of phlogiſton. The calx of lead may be eaſily reſtored to its metallic ſtate, by means of reduction, as above mentioned in the caſe of copper. Lead combines with all the acids; but requires a boiling heat to its commenſtruation with oil of vitriol; and, alſo, that the acid ſhould be in a concentrated ſtate. By vinegar it is moſt perfectly diſſolved; affording ſemi-tranſparent chryſtals; which, from their ſweet flavour, are called ſugar of lead. It alſo combines with ſome ſubſtantial oils of vegetables; with ſulphur, and hepar ſulphuris; and is ſaid to be diſſolved by a ſolution of lixiviate ſalt; and, by long digeſtion, to form a white mucilage with a ſaturate ſolution of volatile alkaline ſalt. Lead combines, alſo, with all metallic bodies, except iron; with which it will not commenſtruate, but under a vitreous form when both are reduced to the ſtate of ſcoria; or the iron, to that of a magiſtery, or calx, and the lead to that of ſcoria. Lead is not only prone, when in a calcined ſtate, to aſſume a vitreous form itſelf; but alſo promotes in a great degree the vitrification of all other vitreſcent bodies. It differs from gold, and ſilver, *in wanting the peculiar qualities of perfect metals*; and *in having a leſs ſpecific gravity*:—from other metals, *in being of a greater gravity, and ſofter*; and *in affording an orange red calx, and yellow glaſs per ſe*:—from the reſt of the metallic bodies, *in having all the proper qualities of metals*:—and from all other ſubſtances, *in having the characters of a metallic body.*

Lead is, though very rarely found, in a native ſtate. It is therefore moſt generally obtained from ores: the moſt common kind of which is known among metallurgiſts by the name of *galena teſſulata*: but where it ſeems compoſed of ſlender oblong plates, it is called *galena granulata*, or *galena ſubtiliter ſtriata.* There are alſo other ores of lead which are diſtinguiſhed by the names of *red*, *green*, *white*, and *grey*: though none of them are common, and the white and grey, but very rarely found. The ore of lead is principally a combination of that metal with ſulphur: but it is ſometimes blended with lapidaceous earths, and other ores; and frequently combined alſo with arſenic.

Lead may be recovered from the ſubſtances, with which it is combined in the ſtate of ore, by elutriation, uſtulation, reduction, eliquation, and fuſory precipitation.

TIN has, alſo, all the qualities aſcribed to metals in general. It is of a white colour not greatly varying from that of ſilver; and being only ſeven times as heavy as water, is conſequently lighter than any other metal. It is alſo fuſible with leſs heat: and is leſs fixt; being calcined into a white earth, if expoſed to the heat for a due length of time with acceſs of air, and an expanded ſurface. It is likewiſe leſs malleable, and tenacious, than any other metal: but harder and more reſiſting than lead. Tin combines with all acids; but moſt perfectly and freely with ſpirit of nitre commixt with a tenth or twelfth part of oil of vitriol: which compound, as has been before obſerved, is moſt properly called aqua fortis; though ſpirit of pure nitre is moſt frequently called ſo. Tin combines alſo with mineral ſulphur, hepar ſulphuris, and, as is ſaid, with olive oil. It reſiſts perfect vitrification; but combining, under due heat, with vitreous bodies; it gives a turbid or milky whiteneſs to the glaſs. Tin differs from gold and ſilver, *in wanting the qualities peculiar to perfect metals*:—from the other metals, *in being of leſs ſpecific gravity*; *leſs malleable*; *leſs fixt*; *fuſible in a leſs degree of heat*; and *in affording a white calx*:—from other metallic bodies, *in having the qualities peculiar to metals*:—and from all other ſubſtances, *in having the proper characters of metallic bodies.*

Tin is very rarely, if ever, found in a native ſtate; though there are ſome writers on metallurgy, of good authority, who aſſert they have ſeen ſuch. It is, therefore, obtained from ores; which are diſtinguiſhed into the black; white; and the common, which is brown, yellow or red.

Tin

Tin may be ſeparated from the mineral ſulphur, iron, arſenic, ſtones, or lapidaceous earths, with which it is commixt while in the ſtate of an ore, by elutriation, uſtulation, colliquation, and reduction.

Iron has all the qualities common to metals. It is of a ſhining grey colour; and is ſeven times and a half as heavy as water. It is the hardeſt, and moſt tenacious, of all metals; and requires the greateſt degree of heat to its fuſion: and being fuſed, it is more fixt than any other imperfect metal; but is nevertheleſs at length, by a continuance of luminous heat with acceſs of air, ſubdued; and reduced to a calx of a reddiſh brown colour; or, with a greater degree, to a dark brown ſemi-tranſparent ſcoria. Iron has, alſo, a peculiar quality not found in any other body; which is its magnetic attraction, that always ſubſiſts in it in ſome degree or manner, while in its metallic ſtate; but is extremely varied by the accidental ſtate of the iron in other points: as alſo diminiſhed by the combination of the iron with other bodies.

Iron combines with mineral ſulphur, hepar ſulphuris, ſolutions of lixiviate and alkaline ſalts, empyreumatic oils, and oleum napthæ. It combines, likewiſe, with all the acids; and alſo with all metallic bodies, except lead and mercury.

The temper of iron in its proper metalline ſtate, is ſubject to be greatly varied, by the accidental changes from heat to coldneſs: as it may, by a variation in this particular, be rendered either more flexible and tenacious, or more rigid and friable, than any other metal in a pure ſtate: and its tenacity is likewiſe greatly increaſed, by percuſſion or forging while luminouſly hot. Iron differs from other metallic bodies, *in its greater hardneſs and reſiſtence to fuſibility*: and from all other ſubſtances whatever, *in its magnetic attraction.*

Iron is never found in a native ſtate; though a ſpecies of ſmall ſtones, reſembling the marcaſite pyrites, are deemed ſuch by ſome: but they may be more properly eſteemed ſtones greatly abounding in iron, than virgin iron. It is, therefore, obtained from ores; of which there is a great variety of kinds both in the form called iron ſtones, and that called ochrous earth: and it is contained alſo in the blood ſtone, emery, magnet, and pyrites of ſeveral kinds. The iron does not, however, for the moſt part exiſt in theſe ores, in a metallic ſtate; but requires the addition of phlogiſton in order to its reduction: this phlogiſton, however, is frequently contained in the ore itſelf; which, after a due calefaction, will give proofs of its metallic ſtate, both with reſpect to the magnet, and commenſtruation with acids, that were wanting before. In other kinds of iron ore, nevertheleſs, it is neceſſary that the phlogiſton ſhould be ſupplied by the addition of ſuch bodies as contain it, in a proper ſtate: but it is not abſolutely requiſite, in order to the reduction of iron, that the heat of fuſion ſhould be adminiſtered: for, contrary to the diſpoſition of metallic bodies in general, it will combine with the phlogiſton in the matter added, even while it remains in an intire ſolid form. Nor is the iron, which is to be obtained from ore by eliquation or fuſion, as it exiſts in its natural condition, ſcarcely ever found in its proper metalline ſtate; for, being combined in ſuch ore with mineral ſulphur, it wants malleability and ſoftneſs of texture; having a hardneſs like glaſs, but without much tenacity; and a great fragility. It therefore requires to be freed, in a certain degree, from the mineral ſulphur, and other heterogeneous bodies, and impregnated with a purer kind of ſulphur, in order to its becoming malleable iron: and in a more perfect degree, in order to its converſion to ſteel. There is, indeed, one inſtance of iron exiſting natively in a malleable ſtate: which is that, to be obtained from a ſpecies of cobalt, found in the province of Weſtmannia in Sweden, by *Mr. Brant*; and by him deſcribed in the *Acta Upſal:* anno 1742.

Iron is ſeparated from the other bodies, with which it is commixt in the ſtate of ore, by reduction, eliquation, and fuſory precipitation, and from the mineral ſulphur, in that degree which conſtitutes forged iron by calefaction and percuſſion; and in the degree which conſtitutes ſteel; by cementation with the coal of animal or vegetable ſubſtances; or by re-fuſion and percuſſion.

SEMI-METALS have all the characteriſtic qualities above aſcribed to metals: but they differ from them, *in having a leſs ſpecific gravity;*

vity; *in their incapacity of being rendered malleable to that degree in which metals are*; *in their being much more volatile, even ſo as to ſublime in the whole of their ſubſtance*; *and in part without decompoſition*:—from mercury, and platina, they differ, *in their much leſs ſpecific gravity*; and, alſo, from the firſt of them, *in their being of a ſolid conſiſtence when cold*; and from the latter, *in their volatility, and fuſibility*:—and from all other ſubſtances they differ, *in having the qualities peculiar to metallic bodies.*

ZINC (in Engliſh called alſo *ſpelter*) is claſſed the firſt of the ſemi-metals. It poſſeſſes the proper characters of a ſemi-metal: and is of a bluiſh grey ſhining colour; with a kind of laminated texture, as appears when it is broken. It fuſes with that proportion of heat, which gives it the firſt degree of luminous redneſs: and, if it be not urged too ſtrongly, calcines to an earth reducible according to the manner above mentioned: but, if a greater degree of heat be adminiſtered, it yields a beautiful green flame; and ſublimes almoſt wholly away, partly without decompoſition, and partly in a decompounded ſtate: the phlogiſton ſuffering that change which combuſtion always produces; and the metallic baſis of the zinc, of which a great part may be collected, if the calcination be performed under a chimney, either in the form of flowers, or in more concreted maſſes called the *cadmia fornacum*, being reduced to a ſtate in which it is incapable of reduction by any means hitherto known. Zinc refuſes all commenſtruation with mineral ſulphur, even though combined with lixiviate ſalts in the form of hepar ſulphuris; to which all other metallic bodies yield; but is ſaid to be diſſolved by the ſolution of lixiviate ſalt combined with the fixt ſulphur of animal ſubſtances; as, alſo, by a ſaturate ſolution of volatile alkaline ſalt. It combines, however, freely with the mineral acids, particularly oil of vitriol; with which it forms the metallic neutral ſalt, called *white vitriol:* and it commenſtruates, likewiſe, with all the metallic ſubſtances, except biſmuth, with which, though there is the greateſt affinity of nature betwixt them in other reſpects, it will not combine. With copper it combines, even in the proportion of a third part, without taking away the malleability of it: but there is a great difference in the compound formed of thoſe two metals, from the manner of combination. For, if the copper be impregnated with the zinc by means of cementation with the lapis calaminaris, which contains a large quantity of zinc, braſs will be produced: but, if they be combined by means of fuſion, a compound, differing in colour and other properties, and commonly called the *Princes* or *Bath-metal*, will be formed.

Zinc differs from metals, *in wanting the qualities which make their peculiar character:*—from the other ſemi-metals, *in its greater malleability, and tenacity:*—from the anomalous metallic bodies, *in poſſeſſing the qualities pecu-*

liar to ſemi-metals, and wanting thoſe in which they vary from them:—and from all other ſubſtances, *in having the qualities which give the proper character to metallic bodies.*

Zinc has not been hitherto found in a native ſtate. It is, therefore, obtained from ores, which are not, however, proper to this metal, but are congeries of the ores of other metallic bodies, commixt alſo, for the moſt part, with lapidaceous earths and ſtones. Zinc is, alſo, contained copiouſly in the lapis calaminaris: which, indeed, may be eſteemed a proper ore of zinc; though it does not admit of being ſeparated from this ſtone in a metallic ſtate, by the ſame means as from the mixt kinds of ores. Zinc is recovered from the ores, or other bodies with which it is combined by ſublimation, or rather diſtillation; as it does not admit, like other metallic bodies, of being ſeparated by eliquation or fuſory precipitation.

BISMUTH, called, alſo, in Engliſh *tin glaſs*, has all the proper characters of a ſemi-metal, and reſembles zinc in its appearance; except inſtead of having a bluiſh caſt in its colour, it inclines towards a reddiſh yellow. It is the moſt fuſible of all the ſemi-metals; and when commixt with them, even promotes greatly the fuſion of metals: and it is yet the moſt fixt of the ſemi-metals; and has no ſenſible detonation with nitre; though it may, by a ſlower effect, be calcined through its means: or, being acted upon by a ſtrong fire, it may be ſublimed in flowers; and with a leſs degree, duly continued, converted firſt into a calx; and, afterwards, into a vitreous body: both which are, nevertheleſs, reducible into a metallic ſtate, by the reſtoring the phlogiſton exhaled from it. It is extremely fragile, and wanting almoſt every degree of malleability. Biſmuth combines, through fuſing heat, with mineral ſulphur, hepar ſulphuris; and, being reduced to the ſtate of a magiſtery, with the ſolution of lixiviate ſalt combined with the fixt ſulphur in the coal of animal ſubſtances; and it is ſaid, alſo, with a ſaturate ſolution of volatile alkaline ſalt. It combines, alſo, with all the mineral acids, but not perfectly with oil of vitriol: requiring both a concentrate ſtate, and a boiling heat to its corroſion by that acid. Being diſſolved with the nitrous acid, it may be departed from it by the bare effuſion of water affording a magiſtery extremely white. Biſmuth combines, alſo, with all the metallic bodies, except zinc: but, though it may be commixt with zinc, while in a fuſed ſtate, in one ſeemingly united body; yet, on their growing cold, the biſmuth will be found to be ſeparated from the zinc, forming, as it were, a ſtratum under it. It appears to have leſs phlogiſton in its decompoſition than either any of the imperfect metals, or ſemi-metals, from its having no ſenſible detonation with nitre.

Biſmuth differs from metals, *in wanting the qualities that make their peculiar character*;—from the other ſemi-metals, *in its greater fixity*;

fixity; *in its colour's verging towards a reddiſh yellow*; and *in its greater proneneſs to fuſibility*:—from the anomalous metallic bodies, *in having the characteriſtic qualities of ſemimetals*:—and from all other ſubſtances, *in having the combination of qualities peculiar to metallic bodies.*

REGULUS OF ANTIMONY has all the proper characters of a ſemi-metal: and is of a greyiſh white colour; and very fragile. Being calcined with a moderate heat, it is firſt converted to a grey calx; and, afterwards, into glaſs of a ſtrong red colour, inclining to the orange. But being ſubjected to a greater heat, it ſublimes away in its whole ſubſtance; and, in its avolation, volatilizes, or carries off with it, a conſiderable proportion of any other metallic body combined with it, except gold and platina. Being, otherwiſe, commixt with a ſufficient proportion of nitre, and expoſed to a fuſing heat, it is calcined by detonation into a calx of a perfect whiteneſs.

Regulus of antimony combines with mineral ſulphur, hepar ſulphuris, the ſolution of lixiviate ſalt, and, as is ſaid, by the mediation of alkaline ſalts fuſed with it, with alcohol. It combines with all the mineral acids; and with all metallic bodies, except mercury: but with that it refuſes all commenſtruation, notwithſtanding the combination pretended to be made by the means invented by Henckel. For nothing more is effected by that operation, (which will be deſcribed below), but a meer commixture of the two ſubſtances; as the regulus wholly ſeparates from the mercury in a very ſhort ſpace, if they be ſuffered to ſtand at reſt. Antimony, being mixt with vitreous fluxes, or glaſs, in a large proportion, vitrifies imperfectly; giving at firſt a yellow opake colour to the glaſs: but by longer continuance of the heat, it becomes tranſparent, and verges in its colour to red.

Regulus of antimony differs from metals, *in wanting the qualities peculiar to them*:—from all the other ſemi-metals, *in requiring a much greater heat to its fuſion*; and from zinc, alſo, *in being leſs malleable*; biſmuth, *in being leſs fixt, and of a clear white colour, not inclining to yellow*; and regulus of arſenic, *in being more fixt, and whiter*:—from the anomalous metals, *in having the proper characters of a ſemi-metal*:—and from all other ſubſtances, *in having the qualities peculiar to metallic bodies*.

Regulus of antimony is not known to exiſt any where in a native ſtate; but is found combined with ſulphur, in a compound of a peculiar nature; which has a metallic glittering appearance; and is called *crude antimony*: but being ſometimes, likewiſe, of a reddiſh colour, is then called *red antimony*. This crude antimony is formed principally of ſulphur, and regulus of antimony; but is frequently not devoid of arſenic.

The regulus of antimony is ſeparated from the other bodies conſtituting the crude antimony or its ore, by eliquation, uſtulation, reduction, and precipitation by other metals.

REGULUS OF ARSENIC has the characters of a ſemi-metal: and reſembles, in its general qualities, the others; having their ſhining appearance, with a greyiſh white colour. It is, however, of leſs ſpecific gravity than any other; and likewiſe the moſt volatile; as it flies off quickly in fumes, with a leſs heat than will melt it: and is, therefore, with difficulty kept in a fuſed ſtate; requiring a ſtronger fire than the other ſemi-metals to its liquefaction. The fumes, when collected in a denſer ſtate, form a kind of chryſtalline maſs: and, when in more diffuſed, flowers. The arſenic in this ſublimed ſtate, being then deprived of the phlogiſton neceſſary to that condition, loſes its metallic form; and becomes what is called *white arſenic*; which may, nevertheleſs, be brought back again to its metallic form, by due means of reduction; but, in the mean time, aſſumes a ſaline nature; in which view it has been before fully treated of in Part II. Vol. I. Regulus of arſenic combines with mineral ſulphur, and with alkaline ſalts; as, alſo, with all the metallic bodies, except mercury, and platina according to Dr. Lewis; rendering the metals extremely friable (except copper in ſome proportions); and, alſo, volatilizing them on the acceſſion of due heat; and whitening gold and copper. Arſenic being commixt with vitreſcent bodies, in due heat, promotes greatly their vitrification; and combines with them in a tranſparent glaſs; unleſs when added in a large proportion; in which caſe, an opake white, or milky colour, is produced.

Regulus of arſenic is, ſometimes, though but ſeldom, found in a native ſtate. It is, therefore, recovered from ores: of which the proper are, the white pyrites, orpiment, and cobalt: and it is contained, alſo, in a latent manner, in many various ſtones, and earths. It is not, however, to be recovered from theſe ores, or earths, in its metallic form; but in its calcined ſtate; or, in other words, that of the white or chryſtalline arſenic.

Regulus of arſenic is not to be ſeparated from its ores, by eliquation, or fuſory precipitation, as moſt of the other metallic bodies are; but muſt be obtained, as zinc, by ſublimation, though not in a metallic, but calcined ſtate; from whence it muſt be brought to the form of a ſemi-metal by reduction.

REGULUS OF COBALT is little known, not being noted as a diſtinct ſemi-metal before the year 1729, when Mr. Brant laid an experimental examination of it before the Royal Society at Upſal, in which he demonſtrates it to be a diſtinct ſemi-metal. It agrees with the other ſemi-metals in its general qualities; but has the remarkable property of combining in a large proportion with iron, without diminiſhing the magnetic attraction of it: ſeeming, on the contrary, itſelf to acquire the ſame attractive power by its commenſtruation with the iron: which preſerves, alſo, its malleability during its union with this ſemi-metal, contrarily to what happens in the caſe of all others. The regulus of cobalt, mixt with vitreous fluxes or glaſs, is, with the acceſſion of due heat, converted to blue glaſs, in the ſame manner as ſmalt; which is the recrementitious earth of the cobalt after the arſenic, and regulus, where that is preſent, are reſeparated.

Regulus of cobalt does not appear to have ever been found in a native ſtate: nor is hitherto introduced into any uſe with reſpect to œconomical application. That which Mr. Brant made the ſubject of his examination, was obtained from a particular kind of cobalt, found in Sweden and ſome other places, by diſſipation of the arſenic, and reduction according to the uſual means.

NICKEL is the other of the ſemi-metals not hitherto admitted into the uſual enumeration of the metallic bodies of that claſs. It was firſt brought into public notice by Mr. Cronſtod, in an account of it given to the Royal Academy of Upſal, in the year 1751. It agrees with the other ſemi-metals, as far as appears hitherto, in its general character: and, not having any peculiar qualities at preſent diſcovered that can render it uſeful, it is not applied to any œconomical purpoſe.

The ANOMALOUS, or HETEROCLITE METALLIC BODIES, poſſeſs the general properties of metallic bodies: but differ from both the metals and ſemi-metals, in ſome of thoſe qualities, which are eſſential to the ſpecification of either of thoſe claſſes.

PLATINA, according to the moſt authentic account of the experiments hitherto made on it, may be deemed an anomalous metallic body; and may be properly ranked as the firſt of them, from its nearer approach to the nature of metals. It is of a white colour, much reſembling that of ſilver. According to the ſtate, with reſpect to purity, in which it has been hitherto examined, it is more than eighteen times as heavy as water; but it is probable, that in a perfectly pure ſtate, it may prove of equal, or greater ſpecific gravity than gold. It is not fuſible in any degree of heat, without the admixture of other metallic bodies: but, with them, runs into fuſion; in degrees of heat, that vary with the different ſpecies of metallic bodies added: and it is not only infuſible by heat, but remains unchanged, as gold or ſilver, in the ſtrongeſt that can be produced on the principle of culinary fire. It is not without ſome ſhare of malleability; but breaks with forcible ſtrokes; and may be then even pulverized. It combines with hepar ſulphuris; but not with crude ſulphur; and with aqua regia only among the acids. It combines with all the other metallic bodies: but with reſpect to arſenic, there is ſome doubt; as will appear from the reaſons given below. Being mixt with vitreous fluxes, or glaſs, it is not like the other metallic bodies converted into glaſs; but ſeems merely to commix with it; inducing an opake appearance.

Platina, being diſſolved in aqua regia, is not precipitated by green vitriol, like gold, nor even with the vitriolic acid in its ſimple ſtate, provided the ſolution be previouſly diluted with water; nor does the ſolution give either a purple or black tinge to feathers, or other animal ſubſtances; though a ſolution of gold ſtains with the firſt of theſe colours; and a ſolution of ſilver with the other: nor, being precipitated with tin, is the magiſtery of a crimſon red colour. The ſolution being, however, ſuffered to ſhoot, produces chryſtals of a dark almoſt opake red colour; and of a flaky form: but, being commixt with alcohol, no ſeparation of the platina from the aqua regia enſues, as in the caſe of gold: nor is a perfect precipitation to be made by the addition of alkaline ſalts, or any of the metals ſingly; a proportion, ſufficient to give a ſtrong yellow colour to the fluid remaining undeparted.

Platina, combined with the metals, gives hardneſs and brittleneſs to them; particularly to lead: and, in a large proportion, takes away the malleability of all of them, when in their perfect ſtate: but to iron, in its crude ſtate above deſcribed, in which it is called *caſt iron*, it gives ſome degree of that quality. Tin ſuffers the moſt, in its malleability, by platina: gold, and ſilver, the leaſt. Platina renders the yellow metals paler: which effect is not, however, produced ſenſibly in either gold, or copper, by the admixture of a ſmall proportion of it: but by leſs in copper, than in gold. The colour of the white metals is alſo injured by it: but that of ſilver the leaſt, and of lead, the moſt. Platina increaſes the hardneſs of zinc, and regulus antimony; but not of biſmuth. It reſiſts the volatilizing power of antimony; and the corroſive action of the royal cement: and even prevents the vitrification of lead, combuſtion of zinc, or calcination of antimony, when combined with them in a ſmaller proportion: which evinces that it imparts its indiſtructibility, and unchangeableneſs by fire even to other metals.

Platina, therefore, differs from metallic bodies in general, *in being wholly infuſible without addition:* and from metals in particular, *in having only a ſmall degree of malleability, and being invitrifiable.* From gold, in particular, with which it agrees nearly in its ſpecific gravity; in its refuſing combination with all acids but aqua regia, and, likewiſe, with ſulphur; and in its reſiſting the volatilizing power of antimony; it differs, alſo, *in that the ſolution of it in aqua regia does not, on precipitation, afford a crimſon red or purple magiſtery; nor ſuffers a depart of any part of the platina by the addition of green vitriol, or of the vitriolic acid when diluted with water; nor is even wholly precipitated, even by the addition of any other ſalt or metallic body ſingly;* as alſo *in defending ſome proportion of lead, zinc, or antimony combined with it, from the action of the ſtrongeſt fire.* From ſilver in particular, with which it agrees in its colour, it differs *in its greater ſpecific gravity; in its refuſing combina-*

tion with ſulphur, and with all the acids but aqua regia; and *in the colour of the magiſtery and other circumſtances reſpecting its ſolution, as before from gold.* From the imperfect metals in particular, it differs *in its fixity and unchangeableneſs under every degree of heat*; *in its ſpecific gravity*; and *in its refuſing combination with ſulphur, and all acids but aqua regia.* It differs from ſemimetals in particular, likewiſe, *in its infuſible per ſe*; *and in its being invitrifiable, and abſolutely fixt*: and from all other ſubſtances, *in having that combination of qualities which makes the ſpecification of metallic bodies.*

What the ores are from whence platina is obtained, in its original mineral ſtate, is not hitherto known in this part of the world: there being great reaſon to believe, that moſt of the ſpecimens brought to Europe had undergone ſome operations, in order to the ſeparation of what gold might have been mixed with the platina in thoſe mineral maſſes in which it was found. There are but two of theſe ſpecimens well deſcribed: which are thoſe of Mr. Sheffer, and Dr. Lewis: and they varied, according to the different accounts, from each other. The firſt was compoſed of grains reſembling black ſand, of grains of pure gold, and of grains of platina, in a metallic form, that appeared to be of a triangular figure with plain ſides: ſome of which being diſcoloured by a ferruginous duſt, which adhered to them, and occaſioned the magnet to have ſome weak action on them, were miſtaken for iron ore. The other ſeemed to be the ſame, but with the addition of ſome particles of mercury; and of two other ſubſtances, the one like ſpar; and the other pit coal; with which it gave the ſame appearances when burnt.

The platina has been but very lately known in Europe. The firſt public notice, that has been taken of it, was in the relation of the voyage made to Peru by Don Antonio Ulloa, publiſhed at Madrid in 1748; but which gave indeed very little light into its nature: that gentleman not being at all verſed in matters of this kind. But, before that time, Mr. Charles Wood had brought ſome ſpecimens from Jamaica to London: and in 1750 theſe ſpecimens, with an account of Mr. Wood's experiments on them, were laid before the Royal Society of London, by one of their members, Mr. Watſon, a zealous cultivator of natural philoſophy. Mr. Wood's experiments extended no farther than to the mixing the platina by fuſion, with gold, ſilver, copper, and tin; the cupelling it with lead; and the trying to diſſolve it in aqua fortis. In the year 1751, Mr. Sheffer publiſhed a deſcription, and experimental examination of the platina, in the Memoirs of the Royal Academy of Sweden: which examination was extended further than that of Mr. Wood: but Dr. Lewis, in the year 1754, publiſhed in the Memoirs of the Royal Society of London, a much more ample account of the experimental nature of this ſubſtance than had been before given. There are, however, ſome remarkable variations in the accounts of theſe two gentlemen, with reſpect both to the ſenſible properties of the platina, and the reſult of their experiments on it. For Mr. Sheffer ſays, in his account, in one place, that *this metal was as malleable, as any iron can be:* and, in another place, *that it has the hardneſs of forged iron.* Dr. Lewis, on the contrary, ſays, “ *that though ſome of the purer grains bore to be* “ *conſiderably flattened, when laid on a ſmooth an-* “ *vil, by the gentle ſtrokes of a flat hammer; yet* “ *others quickly cracked; and the whole were re-* “ *ducible into powder, by rude ſtrokes, in an iron* “ *mortar.*” According to him, therefore, this ſubſtance is ſo far from being as malleable as iron, that it does not poſſeſs this quality in an equal degree even to one of the ſemi-metals: and if there were really no difference, with reſpect to purity, in the ſpecimens of platina examined by them, one would wonder, that Mr. Sheffer ſhould fall into ſo extraordinary a miſtake; unleſs, by preſuming, from ſlight trials, in which he perceived this ſubſtance to be in ſome degree malleable, that it was, therefore, greatly ſo: for with relation to Dr. Lewis, one can ſcarcely believe he erred in this particular: as he was not limited in the quantity of the ſubject matter; and appears to have been very accurate and elaborate in his experiments in moſt other points. Another circumſtance, in which they differ from each other; is, with reſpect to the combination of the platina with arſenic: for Mr. Sheffer ſays, that, *with an addition of arſenic, the compound was brought as eaſily to fuſion, as copper* *or iron joined to arſenic; and that this would happen equally, even when only one part of arſenic was put to twenty four of the platina:* and, moreover, *that there is no occaſion to uſe any flux for this compoſition, as is neceſſary when arſenic is to be combined with iron or copper; but, that as ſoon as a little portion of the arſenic is put into the crucible to the platina (which ſhould be previouſly made red hot) the whole melts in the twinkling of an eye.* Contradictorily to this, Dr. Lewis ſays, in his general remark on the experiments he has given reſpecting the combination of the platina with the ſemi-metals; “ *This extraordinary* “ *mineral, on which the moſt active fluxes,* “ *aſſiſted by the moſt intenſe fires, have no effect,* “ *melts perfectly with all the known metallic* “ *bodies; unleſs arſenic, a ſubſtance impatient* “ *of a degree of heat ſufficient to render itſelf* “ *fluid, is an exception:*” which, in the ſenſe I underſtand this paſſage, amounts to affirming, that arſenic, on account of its too great volatility, cannot be, by any means, combined with platina. I take it, therefore, for granted, that Dr. Lewis did not advance this notion without having made ſome experiment, on which he might ground it: though a foreign writer has conceived the fact ro be otherwiſe; and ſays very unwarrantedly: “ *Mr. Lewis* “ *ne vouloit pas ſeulement eſſayer cette combinaiſon,* “ *croyant que ce ſeroit le comble de l'extrava-* “ *gance de vouloir unir par la fuſion le corps le* “ *plus fixe & le plus refractoire de la nature,* “ *que nulle violence du feu ne pouvoit ſubjouguer,* "*à un autre que s'evaperoit à la moindre chaleur.*" It were to be wiſhed, however, the Doctor had expreſſed himſelf with more preciſion on this material article: or rather given the experiment of the effects of the mixture of arſenic with platina in due heat, at large; which ſeems wanting to the completion of his profeſſed intention (according to the title of the paper, which is PAPER IV. PLATINA MIXED WITH SEMI-METALS) of ſhewing the effects of the mixture of platina with the ſemimetals; and not ſlightly touched upon it, in a parentheſis, in the remarks on other experiments. But ſuppoſing that this was ſaid on good foundation, how is it poſſible to reconcile ſuch difference in the two writers, in a point that is too ſimple in its nature to admit of a miſtake; and turns upon an experiment in Mr. Sheffer's caſe, which is too circumſtantially related to make any allowance of that kind in his favour, if the fact be really otherwiſe? There is another circumſtance in which Mr. Sheffer, however, appears clearly to have fallen into an error; which is, in ſuppoſing that the platina, though it could not be fuſed without addition, by any degree of heat, while incloſed in a crucible or melting pot, might yet be brought to that ſtate, by being expoſed to the action of the heat in the naked fire, in contact with the coals. But Dr. Lewis, who has expreſſed himſelf well aware of the difference, in the two manners of applying heat, has related an experiment, made on this principle, with all the advantages that his great knowledge and ſkill in theſe matters could ſuggeſt; in which it appears, that, where the platina was kept free from other metallic bodies, the heat had no more effect upon it, when in contact with the burning fewel, than when incloſed in melting pots; and the platina may, therefore, on the juſteſt grounds, be concluded, to be abſolutely infuſible, when not mixt with ſome other metallic body, in every degree of heat producible on the principle of culinary fire.

I have, therefore, differed from Mr. Sheffer, and ſome others, who have called the platina a perfect metal; and have claſſed it along with mercury, as an anomalous metallic body; as it wants fuſibility per ſe, and vitrifiability; which are eſſential qualities of both metals and ſemi-metals; and as it varies, moreover, from metals, in its want of the capacity of becoming malleable in the degree that is made generally the mark of ſpecification betwixt metals and ſemi-metals; and from ſemi-metals, in its fixity; which is the diſtinguiſhing character of perfect metals; and makes it, conſequently, recede very far from the nature of ſemi-metals. As it, therefore, differs from both metals, and ſemi-metals, in two eſſential points of ſpecification; and, from each kind in particular, in others, it cannot certainly, with any propriety, be ranked with either: but muſt be conſidered as of a third claſs; and, there being none other that agree with it in theſe particulars, ſuch claſs muſt be, that formed of thoſe metallic bodies, which agree with metals and ſemi-metals in thoſe properties which are common to them all; but vary from both in ſome particulars that are ſpecifically eſſential to each kind ſeparately; and have, moreover, peculiar qualities not found in any other. Dr. Lewis, accordingly, has judiciouſly avoided naming it either a metal, or ſemi-metal; but called it, with great propriety, *a metallic ſubſtance.*

MERCURY has all the characters above aſcribed to metallic bodies; except that, by the ſuperaddition of conſtant fluidity, a negation accrues of the relations, on which the property of fuſibility is founded. It is fourteen times as heavy as water; but yet ſo volatile, that, with a ſomewhat leſs than luminous degree of heat, it exhales in fumes; but being condenſed again, on meeting with a colder medium, it reaſſumes its proper fluid form. It ſeems, likewiſe, to be calcined, on being long kept in a heat leſs than will volatilize it; and is, by ſuch means, converted to a reddiſh powder: but the increaſe of weight, and other attendant qualities of this powder, ſhew it to be formed rather by accretion of another body to it, than the analyſis of the mercury: nor is it to be any other way analyzed, by any known means.

Mercury combines with ſulphur; and, as is ſaid, when in the ſtate of a magiſtery, or calx, with a ſolution of lixiviate ſalt, combined with the fixt ſulphur of the coal of animal ſubſtances: and alſo, but in a more imperfect manner, with the balſam of ſulphur, turpentine, and alkaline earths. It combines perfectly with all the mineral acids; though it is required, in the caſe of oil of vitriol and ſpirit of ſalt, that they ſhould be in a very concentrate ſtate. It is ſaid, alſo, to combine with vinegar; being previouſly calcined or reduced to the ſtate of a magiſtery. Mercury, alſo, combines with all the metallic bodies, except iron, and regulus of antimony: though with the laſt, it is ſaid a combination may be made by particular means: but with reſpect to the regulus of antimony it was before ſhewn to be erroneous; and with reſpect to the copper it is imperfect. The combination of biſmuth and mercury ſeems only to exiſt while the compound is in a certain degree of heat; for, on their being ſuffered to ſtand at reſt after they are grown cold, the biſmuth ſeparates from the mercury in the form of a powder. With copper, alſo, the combination is ſo imperfect, that, notwithſtanding the proceſſes given for it by Boerhaave, Kunkel, and many other writers, I could never effect a proper amalgamation, nor could learn from others, on whom I could depend, that any ſuch had been made. Mercury does not admit of being vitrified; nor enduring a ſufficient heat, even in the ſtate when moſt fixt, by combination with acids.

Mercury is ſometimes found in a native ſtate, but more frequently in that of an ore, of which there is but properly one kind, called *native cinnabar*: but it frequently, as well as the virgin mercury, is commixt with other ores, and lapidaceous earths.

Mercury may be ſeparated from other foſſile bodies, when in a native ſtate, by ſimple diſtillation; but, when in the form of cinnabar, alkaline earths, ſalts, or other metallic bodies, muſt be added, to procure a depart of it from the mineral ſulphur.

Metallic bodies are the object of experiment, with reſpect to their decompoſition, and reduction:—the change of their form, or other qualities by combination with each other:—their ſeparation from each other:—the deſtruction of their ſpecific form, by combination with ſubſtances of diverſe genera:—their ſeparation from other bodies, and from bodies of diverſe genera:—and the change of their texture, or colour, while retaining their ſpecific form.

The means of the decompoſition of metallic bodies, is by heat alone: and it can be only effected on the principle of combuſtion, through the means of the ſpirit of nitre, either in the air, or in nitrous ſalts added. In both which caſes, the ſpirit of nitre, either in the air, or ſalt, commenſtruates with the phlogiſton, and renders the ſeparation of the metallic body a decompoſition, and not an abſolute analyſis, according to the difference before ſtated betwixt them.

The means of reduction of metallic bodies to their perfect ſtate, when in that of a ſimple calx, or earth, is by the addition of ſome body containing phlogiſton in a due ſtate; as the coal of animal or vegetable ſubſtances: but it is neceſſary, in all inſtances, except that of iron, there ſhould be ſuch a degree of heat as will fuſe the ſubſtance when reduced: but in thoſe caſes where the calx is combined with acids or mineral ſulphur, the uſe of alkaline ſalts or lime, to make a previous depart, is neceſſary.

The change of the form, or other qualities of metallic bodies, by the combination of them with each other, is brought about, by ſimply fuſing them together: except in the inſtance of mercury; which, being a fluid, may be made to unite with ſome kinds, without heat. There is a caſe, likewiſe, where cementation, or the vaporous ſtate of one of the bodies, is neceſſary to the combination, if required to be productive of peculiar qualities in the compound; which is in the inſtance of the combination of copper and zinc, for the formation of braſs: which two metallic bodies, if fuſed together, yield a very different compound from that produced when they are combined by cementation.

The ſeparation of metallic bodies from each other is performed by various means: as fuſory precipitation; cupellation; departure; volatilization by heat, ſimply, or through the admixture of other bodies; and by calcination: the manner of conducting which operations, being various with reſpect to the ſeparation of different metallic bodies from each other, will be ſhewn in the reſpective experiments on thoſe bodies.

The deſtruction of the ſpecific form of metallic bodies by combination with other ſubſtances, is effected, in moſt caſes, by means of the commixture of them with ſuch ſubſtance; and the circumſtances requiſite, are thoſe which are neceſſary according to the laws of commenſtruation: but there are ſome inſtances, where no mechanical commixture is made; the combination being brought about by the acceſs of the other body to the metallic, under the ſtate of fumes or vapour; in which caſe, as was before obſerved, the operation is called *cementation*.

The means of ſeparation of metallic bodies from thoſe of diverſe genera, whether combined, or only ſimply commixt, with them, are extremely various, according to the nature of the combination or commixture of them. In many caſes of their combination with ſuch bodies of other genera, as are not of a fixt nature; as the acids, ſulphur, and phlogiſton, it may be done by heat, on the principle of ſimple incaleſcence; in moſt others a departure is neceſſary, either by the reduction of the metal, or by the combination of the body ſuperadded with thoſe compounded with the metallic body. Where other bodies are commixt, but not combined with the metallic bodies, mechanical means are uſed for their ſeparation, which are generally grounded on the difference of the ſpecific gravity betwixt the metallic and the other bodies. The moſt general operation of this kind, is that performed by the medium of water, as above deſcribed, and called *elutriatiom* or *waſhing over*. In the caſe of iron, if in a pulverine ſtate, the magnetic attraction may be employed, and will make an effectual ſeparation: and diſtillation will perform the ſame with reſpect to mercury, and the amalgamating power of the mercury itſelf is, likewiſe, an effectual means of ſeparating ſome metallic from all other bodies not combined with them. In the ſeparation of metallic bodies from each other, the means are equally various; but as they each make the object of diſtinct experiments below, it is needleſs to enumerate them here.

The fuſion of metallic bodies is produced, as that of others, by heat, either with or without addition; but there is one inſtance, which is that of platina, where no liquefaction can be made of the body by the heat of culinary fire, without the aſſiſtance of another metallic body combined with it: and in many other caſes, alſo, additions of fluxes, or ſuch ſubſtances as promote the liquefaction, are expedient.

The volatilization of metallic bodies is performed by heat, either with or without additions. The metals are not eaſily made to ſublime in their intire ſtate, by the heat of culinary fires, without the admixture of other bodies: but the ſemi-metals, particularly zinc, and arſenic, are to be ſo ſeparated from the other ſubſtances, with which they are originally found conjoined in their foſſile ſtate.

The vitrification of metallic bodies is brought about, either by heat ſimply, or with the addition of other bodies; but lead and antimony are, indeed, the only kinds that yield to be perfectly vitrified by the heat of culinary fire, without addition of ſome other ſubſtance: In moſt caſes, therefore, the vitrification of them is performed by the joint action of heat, and fluxes: which, as was before obſerved, is the term uſed to expreſs bodies added to others in this intention: but the large burning glaſſes, nevertheleſs, vitrify all the metallic bodies that are ſufficiently fixt to abide the action of ſo intenſe a heat, but gold and ſilver; and, as may be juſtly preſumed, platina.

The change of the ſenſible qualities in metallic bodies, without addition or deſtruction of their ſpecific form, which is confined to a few inſtances, conſiſts either in change of texture, which is principally in the caſe of metals with regard to their malleability, tenacity, and what is called *temper*; or their condition with reſpect to flexibility or rigidity: or in the change of colour, which regards only gold and copper, except in ſome caſes of ſteel, where the colour of the ſurface only is affected. The change of texture, with reſpect to malleability and tenacity, is, in moſt inſtances, produced by the rendering the metal purer: unleſs in the caſe of iron; where, as has been before obſerved, a change of the mineral ſulphur for another of a purer kind, ſuch as ſubſiſts in the coal of animal or vegetable ſubſtances, is, alſo, neceſſary; and in the caſe of copper, gold, and ſilver, in a cold ſtate, where the tenacity is, alſo, increaſed by beating it. The temper of metals, of which iron is the chief ſubject, is varied by the heating them red, or white, hot: and either preventing their cooling, except by very ſlow degrees; or accelerating it in the quickeſt manner, by immerſing them in cold water. For the ſlower the heat leaves them, and the more flexible and ductile they become; and, *vice verſa*, the more ſuddenly they are cooled, and the more rigid and brittle they grow. The change of colour in gold is produced by fuſion with borax, and nitre; or ſea ſalt, or any other ſubſtance, of which the acid of ſea ſalt makes a part; or, otherwiſe, by cementation with ſea ſalt, and ſuch bodies as may depart the acid from it; or with other bodies combined with that acid, in ſuch manner, that it may be ſeparated through heat. A ſuperficial change of colour in copper, and ſteel, are brought about, by expoſing them to flame, or to the fumes ariſing from bodies, in a burning ſtate.

CHAP.

CHAP. II.

Experiments and particular obſervations on metallic bodies.

SECTION I.

General experiments relating to metallic bodies, and obſervations on them.

EXPERIMENT I.

Separation of metallic bodies, or their ores, from ſtones, earth, or other heterogeneous ſubſtances, by elutriation.

TAKE the matter, which is intended to be the ſubject of this operation; and, if it be of a lapidaceous conſiſtence, though yet ſo ſoft as to admit of comminution; let it be powdered in a mortar:--or, if it be of the nature of vitreſcent flints; or the calcarious, gypſeous, or ſparry kinds of ſtones, let it be calcined; as was directed in Experiments V. and VIII. Chap. II. Part I. and then reduced to powder. But, if the matter be of the nature of clay or chalk, that will imbibe water; or in the form of a looſe earth, no ſuch previous comminution, or calcination, is neceſſary. Put then this matter, being either naturally in, or reduced by theſe operations to, a due ſtate, into a tray or ſhallow veſſel (which may be either of earth or wood, provided the inner ſurface be ſmooth), ſo as to fill it two or three inches high; and adding water to it, in ſuch proportion, as to riſe about an inch above the powder, let them remain thus, till the earthy part adhering to the metallic be well ſoftened. Another veſſel full of water being alſo made ready, which ſhould be of a ſize ſomewhat greater than the length of the tray, take the tray in the left hand; and immerſe it in an oblique poſition, with the hind part higheſt, into the water; and move it gently, with the right hand, from the fore part, which is the loweſt, to the hind part, which is raiſed higher. Let it now reſt for a ſhort ſpace of time: and then decant off the water, by inclining the fore part of the tray; which will carry off, with it, the light earth raiſed by the water; the heavier metalline part remaining at the bottom of the tray: and repeat this till it be intirely clean. But, if any barren ſtones appear to be mixt with the metalline powder, let the tray be ſhaken, by moving it briſkly in an horizontal direction: and thoſe heterogeneous bodies, that are lighter than the metalline matter, and could not be waſhed away on account of their too great bulk, will riſe to the ſurface, by this concuſſion; and muſt be ſeparated by the hand. The metalline matter being then dried, will be thus freed from all heterogeneous bodies, of an earthy or lapidaceous kind, not menſtrually combined with it.

OBSERVATION.

This operation is previouſly neceſſary, in many caſes of the ores of metals, for their purification from ſtones, earth, and other ſuch heterogeneous bodies; in order to the further ſeparation of the metallic matter from them: and in the inſtances of the more valuable kinds, or where only eſſays or experiments are to be made of ores, the method here given will avail to the end: but where large quantities of ore are in queſtion; as in the caſe of tin, copper, or lead; mills wrought by water are uſed for the comminution; and the elutriation is performed, alſo, by ſmall ſtreams made to flow over the powdered ore. The ſame method may, however, be uſed for ſeparating the metallic bodies themſelves, when mixt, in the ſtate of filings or other pulverilentous form, with common duſt, or other heterogeneous matter not metallic.

EXPERIMENT II.

Separation of metallic bodies from lapidaceous, and terrene ſubſtances, by means of mercury.

Take the ores, waſhed as in the preceding experiment; or any other matter compounded of thoſe metallic ſubſtances, that will combine with mercury, and other heterogeneous bodies, firſt comminuted, and rendered as pure, as it can be that way made, by elutriation. Put the waſhed powder into a veſſel of wood or glaſs; and pour upon it, as much as will riſe above it, of the ſtrongeſt vinegar impregnated with about a tenth part of alum, diſſolved in it by means of heat; and let them remain a day or two in this ſtate. Decant off then the vinegar; and free the powder from what may adhere to it, by ablution, with clean water, till it ceaſe to contract any acidity. Add mercury to the powder, in the proportion of four parts to one; and rub them together, with a broad-ended wooden peſtle, in a proper mortar, till there be no appearance of any powder; unleſs a black kind produced by the globules of mercury minutely divided: and, by this means, the other metallic matter will be combined with the mercury in the amalgamated ſtate. Pour water then to the compound; and continue the trituration for ſome longer time: and, by that treatment, the remaining earth, and other heterogeneous bodies, will be waſhed away; and all the globules of mercury, combined with the other metallic matter, will be collected together. Pour off then the foul water; and add freſh: repeating the trituration, till the amalgamated matter be perfectly cleanſed: and then dry it, by means firſt of ſponge; and, afterwards, of a gentle heat. The metallic matter will thus be freed from any heterogeneous bodies, with which it was commixt, without menſtrual combination, that could not be ſeparated from them by means of elutriation.

OBSERVATION.

This operation is practiſed conſtantly, with reſpect to gold and ſilver, in the purification of it after it is obtained from the mines; and may with expedience be applied to the ſeparating gold, or ſilver, duſt, from any heterogeneous ſubſtances, with which they may, in other caſes, be commixt. The means of recovery of gold, ſilver, or other metallic bodies, from the mercury, when thus combined with it, will be ſhewn below in its proper place. In Germany and other places, where there are mines of gold and ſilver, this amalgamation is performed in mills.

EXPERIMENT III.

Uſtulation of ores, in order to the more eaſy recovery of metallic bodies, from the other ſubſtances with which they are combined in them; exemplified in the inſtance of the ore of lead.

Take ſuch lead ore as requires uſtulation, and pound it, in a mortar, into a groſs powder; of which the particles may be about the magnitude of coarſe ſand. Put it then into a teſt, ſuch as is deſcribed, with the manner of its fabrication, p. 110, Vol. I. rubbed over with red chalk, or calcined vitriol waſhed; and cover the teſt, by inverting another over it; or by a lid which may fit ſo that it may be well cloſed: but let the ore be as much ſpread as poſſible in the teſt. Let the teſt be put into a furnace, under a muffle; and a gentle heat at firſt adminiſtered, which muſt be gradually increaſed, till a luminous degree be produced; and it muſt be continued in that ſtate, till the operation be ended; which will be, when the black colour of the ore is changed to a yellowiſh brown. In ſome ores that are rendered refractory by pyrites, the operation muſt be twice or thrice repeated. The white and green ore of lead require no uſtulation.

OBSERVATION.

The ſame general method muſt be perſued in the uſtulation of the ores of copper and tin, and of gold and ſilver in certain caſes: but with ſome variations, according to the nature of each.

In the caſe of copper, the heat being gradually brought to a luminous degree, it muſt be continued ſo till the ore ceaſe to decrepitate: and then the cover of the teſt muſt be taken off: and the fire gradually augmented, that the ore may be kept continually in a ſmoking ſtate; in order to which, the door of the furnace before the muffle ſhould be left open, that the air may have the freer acceſs; and the matter ſhould be ſtirred about with an iron rod. The ſhining particles will be changed into an intenſe red or blackiſh colour; and, if the ſmall lumps begin to cohere together, decreaſe the heat inſtantly: but, otherwiſe, it muſt be continued ſo long as any fumes ariſe. When, however, no more appear to be emitted, take out the teſt; and, if the grains of ore have not been liquefied ſo as to coaleſce with each other, the operation has ſucceded well: but, if the whole be run together into one maſs, the matter muſt be again ſubjected to the operation, being comminuted with freſh quantities of ore. When the firſt uſtulation is perfected, the burnt ore muſt be then again powdered; and the operation twice repeated without any addition; but the laſt time the fire muſt be ſtronger: and, unleſs the ore ſeem diſpoſed to fuſion, a little ſuet ſhould be burnt under the muffle; and renewed till, the fire being very bright, neither a ſulphureous, or arſenical ſmell, nor any fumes, be longer perceived: a clean fine powder being produced of an intenſe red, or ſometimes of a blackiſh colour.

In the caſe of tin, the fire muſt be gradually raiſed to the degree of a luminous whiteneſs: and muſt be continued till the fumes ceaſe to riſe: and the comminution, and uſtulation, muſt be repeated a ſecond time, till no arſenic remain; which may be diſtinguiſhed by the fœtor; or by taking out the teſt; and holding over it a cold iron plate; which will be ſpotted with white ſpecks, if any arſenic be emitted.

In the caſe of iron, the ore ſhould be firſt groſsly pounded; and then, being put into a teſt, and placed within a muffle in the furnace, it ſhould be burnt for ſome minutes with a ſtrong fire: and then, being taken out and grown cold, it ſhould be finely powdered; and treated as is directed for the uſtulation of copper.

In the caſe of antimony, inſtead of a teſt, uſe a broad ſhallow earthen pot, not glazed: and, if it be not ſuch as will bear a ſtrong heat, when placed in the fire, it muſt be luted: and the ore muſt be ſpread in it thinly; ſo as not to be more than a few inches deep: and put the pot on the hearth, with a few coals round it. Increaſe then the fire, till the ore begin to ſmoke a little; and, in the mean time, conſtantly ſtir it with a tobacco-pipe, that the ſulphur may the more eaſily exhale. If the fire be too ſtrong, the powdered ore will run into grumes, or begin to melt: in which circumſtance, the pot ſhould be taken from the fire, before the fuſion proceed further; and the ore ſhould be re-pulveriſed; and burnt again with a gentler fire. The ore, which was at firſt in the form of a black ſhining powder, will become of the colour of aſhes, and of an earthy texture; as alſo leſs diſpoſed to melt: on which account, the fire may then be increaſed, till the pot, and its contents, be heated luminouſly red: in which ſtate they muſt be continued, ſo long as any fumes appear to riſe. This operation may be better performed, by adding an equal, or double, quantity of powdered coal to the ore: by which means it will be prevented from coaleſcing in grumes: and admit, conſequently, that a ſtronger may be uſed, from whence the operation will be ſooner ended, and the remaining calx leſs burnt.

Ores being compounded, as was before obſerved, of the proper metallic body each contains, with ſulphur, arſenic, and ſometimes other metallic bodies, and lapidaceous earths: and the ſulphur and arſenic frequently abounding in a very large proportion, render all the means ineffectual, at leaſt without great loſs, of ſeparating the proper metallic body of the ore, from the others which are conjoined with it, without a previous ſeparation be made of the greateſt part of ſuch arſenic and ſulphur. The end of this operation is, therefore, to ſublime the ſulphur and arſenic, and even other ſemimetals out of the ores: and in this view it is conſtantly practiſed on the ores of copper, lead and tin; and even of gold and ſilver ſometimes, when they are found refractory: and alſo of antimony, when deſigned for the preparation of the glaſs. It is, likewiſe, frequently neceſſary for the preparation of *lapis calaminaris*; in order to its being uſed for the production of braſs: but, in that caſe, it is done, without the aid of furnaces, in the open air, by fires made under large heaps of the ſtones broken into pieces of a midling ſize: as it is indeed in the caſe of other minerals, where large quantities are to be burnt; either, the ſame method being perſued; or large furnaces, like ovens, being employed: and the operation is then called *the roaſting of ores.*

EXPERIMENT IV.

Separation of metallic bodies from the heterogeneous ſubſtances, with which they are combined in the ſtate of ores, by reduction and fuſory precipitation; exemplified in the caſe of copper.

As the uſe of fluxes are requiſite in the proceſs of this experiment, it is neceſſary to ſhew previouſly the preparation of ſuch as are required.

Take of nitre one part, and of crude tartar dried two or three parts, and grind them firſt ſeparately, and, afterwards, together: this mixture is called the *crude flux*. Having put this matter into an unglazed earthen veſſel, having a narrow neck, and being three times as big as will contain the flux, place it on a moderate fire: and, as ſoon as it begins to flame with an exploſive ſound, ſtop up the mouth of the pot with a cover. The matter will, by this means, after the detonation, be turned into a black coaly ſubſtance; which is called the *black flux*.—Or mix nitre, and tartar, in equal quantities; and deflagrate them in an open crucible; throwing in the matter by a ſmall quantity at a time; and reſting till the detonation be over, betwixt each injection. The matter thus produced is called the *white flux:* but it differs very little in its conſtituence, and yet leſs, in its properties as a flux, from pearl-aſhes, or lixiviate ſalt any other way produced. All theſe fluxes ſhould be kept in veſſels of glaſs, or earthen ware, carefully ſecured by proper ſtoppels from any acceſs of air: for they are extremely prone to deliquiate.

Having prepared the flux, take of lead ore, which has undergone due elutriation, and uſtulation, according to the preceding experiments; and mix, with it, twice its weight of the black flux; and of ſandover, (which is the ſcum taken off glaſs in its preparatory fuſion,) and ſteel filings, a quarter of the weight of the ore before its uſtulation. Grind the whole then together, that they may be perfectly commixt; and put the mixture into a crucible, of which it will not fill a third part: and over it lay ſea ſalt, of the depth of four inches;

preſſing it cloſe down with the fingers. Cover the crucible with a lid fitted to it; or, in default of ſuch, with a leſſer crucible, that, being inverted, will go within the edge of the firſt: and, having luted the joint, dry the lute by a gentle heat. Place then the crucible in the melting furnace, of which the conſtruction is given page 148, Vol. I. and heap up coals round it, ſo that it may be only buried four inches within them: and, manage the fire at firſt, ſo that the crucible may be only juſt red hot. The ſea ſalt will be heard to decrepitate: and a low hiſſing noiſe will ſucceed: during which the heat muſt be continued of the ſame degree: but when all ſeems quiet, freſh fewel muſt be ſupplied to the fire: and it muſt be as quickly as poſſible raiſed, ſo as to melt the whole of the matter: which may be performed by the due heat of a melting furnace in a quarter of an hour. If, on the augmentation of the heat, the hiſſing return, and increaſe much, the openings into the furnace muſt be every where cloſed, ſo as to check the heat as ſoon as may be: otherwiſe, the matter will riſe in foam out of the crucible: or, very probably, the lid will be thrown off: but this accident is only to be apprehended for the firſt three or four minutes after the fire is raiſed. The precipitation being made, which may be known by the ſtillneſs of the matter in the crucible, and the clear white flame iſſuing from it, the crucible muſt be taken out of the fire; and, being placed on the flooring of a dry hearth, muſt be ſtruck ſeveral times with a hammer; that the metal, diſperſed in granules in the bottom of it, may run together; and coaleſce in one maſs of regulus: which, when the crucible is grown cold and broken, will be found to be lead, freed of all other heterogeneous matter; except there were ſilver in the ore; which may be ſeparated from it by the means below given.

This operation may, otherwiſe, be thus performed, where a proper furnace is wanting, in the fire of a ſmith's forge. Let the crucible be placed at the diſtance of three inches directly before the nozzle of the bellows, in ſuch poſition, that one of the corners of the crucible may point towards the bellows: which will render it more ſecure from being crackt by the heat. It ſhould be ſet on a pedeſtal of about three or four inches high, ſurrounded with coals: and then buried in other coals already burning; which will gradually propagate the fire through the firſt, to the bottom: but no uſe muſt, in the mean time, be made of the bellows. The crucible will be thus heated red hot: in which ſtate it muſt be continued till the indications (before mentioned in the other method), of the proper time of raiſing the fire, occur. Let the bellows be then gently moved a little; and, afterwards, kept ſtill; that, by ſuch proper alternations, the fire may be gradually raiſed, till there be no danger of the ebullition of the matter in the crucible: after which, freſh fewel being put on, and the coals ſtirred with the tongs, that they may be no where deficient, particularly betwixt the nozzle of the bellows, and the crucible, a moderate heat of fuſion muſt be raiſed; and the operation completed, as in the above given experiment.

Where lead ore is rendered greatly refractory by pyrites, the uſtulation muſt be performed with a very ſtrong fire: and the quantity of black flux, and ſandover, muſt be greater, and the iron filings omitted: and where it is rendered refractory through earths and ſtones that cannot be ſeparated by elutriation, an equal quantity of black flux, ſandover, and ſome iron filings (unleſs the ore contain iron) ſhould be uſed: and being well commixt, four times the weight, alſo, of black flux ſhould be added.

OBSERVATION.

In the ſame general way, copper, tin, and iron, may be extracted from their reſpective proper ores: the following neceſſary alterations, reſpecting the peculiar nature of each, being made.

In the caſe of thoſe ores of copper, which are originally more free from ſulphur and arſenic, they muſt be commixt with three times their weight of black flux; and, being put into a crucible, only twice as big as will contain it, the mixture muſt be covered half an inch deep with common ſalt. The fire muſt be, alſo, raiſed, after the decrepitation of the ſalt: firſt till the crucible be of a white heat; at which point it muſt be kept for a quarter of an hour; and then to a yet higher degree; and the precipitation will be made in about a quarter of an hour. If the operation ſucceed, a ſolid ſemi-malleable regulus, of a bright yellow colour, will be found; with a ſolid hard ſhining ſcoria, of a browniſh yellow colour: but, if it miſcarry, the ſcoria will be very black, ſoft, and powdery, with grains of bright copper mixt with it: and the regulus itſelf will be unequal and irregular in its figure. If the copper ore be refractory, through ſtones and earth not to be ſeparated by elutriation, proceed as in the caſe of lead in the ſame circumſtances. Or, if the quantity of ſuch ſtones, and earths, be very great, add a ſixth, or a tenth, part of any calx of lead; an equal weight of ſandover; and three times the weight of black flux. The copper and lead will, together, form a regulus: from which the copper may be again ſeparated, by long fuſion in a ſtrong heat, in the manner below directed in the caſe of black copper. For the ores of copper, where previous uſtulation is required, the proportion of black flux ſhould be quadruple; and that of the ſandover double: and the regulus precipitated, being copper combined with other metallic bodies, is called *black copper*. The black copper may be decompounded, ſo that the true copper contained in it may be freed from the other metallic bodies, and rendered perfect, by cupelling it with lead in this manner. Break the black copper into ſmall bits; and, having mixt with it one third of its weight of granulated lead, put it in a cupel into a proper furnace, previouſly heated to a luminous redneſs: and then raiſe the fire, that the lead may be brought to fuſion as ſoon as poſſible. Lower then the heat to that degree which is juſt ſufficient to keep the melted matter boiling; and thus continue it, till the lead be nearly conſumed: when raiſe the heat again, till the lead be wholly deſtroyed. As ſoon as this appears, cover the copper with charcoal duſt: and take the cupel out of the fire. The copper may, by this means, be rendered extremely pure (except with relation to gold and ſilver), and malleable. The black copper may, otherwiſe, be converted to common copper, ſuch as is generally to be found, by roaſting, and repeated fuſions, as is practiſed in the large works where this metal is recovered from its ores.

In the caſe of tin, the conduct of the proceſs may be the ſame as with lead: but as much pitch, as amounts to a quarter of the weight of the ore, may be added: and the fire ſhould be kept low, till the pitch ceaſe to flame, and there be no danger of cracking the veſſel, or making the contents boil over; and then raiſed as quickly as poſſible, to the greateſt degree neceſſary: being that which will thoroughly fuſe the flux.

In the caſe of iron ore, the following flux may be uſed; of the white flux, three parts; of any glaſs of quick fuſion, ſandover, and charcoal duſt, each one half part: the whole to be added in a triple proportion to the ore. The fire ſhould, alſo, be extremely intenſe; and continued for three quarters, or the whole of an hour. But, as from moſt kinds of ore, the iron thus obtained will not be malleable, it may be further purified by the means below given.

EXPERIMENT V.

Separation of metals from the heterogeneous bodies contained in their ores, by reduction and fuſory precipitation, through the means of ſtratification with coals.

Prepare the melting furnace, and form the pot, of which the conſtruction is given page 148, Vol. I., on the pedeſtal, from lute and coals, as directed in page 154, Vol. I.; ſprinkling it with the duſt of a ſmith's forge, ſcoria, or common glaſs levigated; and preſſing it into its due poſition by a globe, or the end of a proper peſtle, as directed in page 152, Vol. I. To the lower hole of the pedeſtal, on the outſide, let another veſſel, like the melting pot, be joined, with lute; that the matter, which flows down from the melting pot through the paſſage in the pedeſtal, may be received by it. Cover this lower veſſel with coals; and fill the furnace with the ſame; that the whole may be dried thoroughly. The nozzle of the bellows muſt be placed in the higher part of the oblong perforation of the furnace deſigned for that purpoſe: and the fire muſt be ſtrongly blown up for a quarter of an hour, or more, till the inſide of the furnace, eſpecially the melting pot, be white hot. Then abate the blaſt, by taking the weights off the bellows; and put in the ore, at ſeveral different times; having been prepared by burning it in an earthen pot, at firſt with a gentle, and, afterwards, with a ſtronger fire, that the greateſt part of the ſulphur may be ſublimed out of it: and ſome filings of iron may be alſo advantageouſly thrown in with it. The ore ſhould be conveyed into the furnace through the opening made for the blaſt of the bellows, ſo it may fall on the coals: leſt if it be thrown againſt the ſide where the air enters from the bellows, it may, when running down in a melted ſtate, be cooled by the blaſt; and the ſcorified part obſtruct the paſſage of the air: on which event, if it happen, the ſcoria muſt be removed by means of a fire hook, or poker bended at the point, and thruſt up the perforation in the fore part of the pedeſtal. At the time each quantity of the ore is thrown in, the furnace ſhould be only two thirds full of coals of a moderate ſize: but, after each addition of ore, a ſtratum, or layer of coals ſhould be put over it: and great care muſt be taken, that, as the refractory ſcoria collects together in a maſs, it may be taken away. Where the end of the experiment is to determine, with accuracy, what the quantity of metal is, that may be afforded by the ore, the ſcoria, being collected together, and powdered groſsly, muſt be thrown again into the furnace with freſh coals: and this may be repeated even a ſecond time, that whatever admits of it may be reduced: the bellows being moderately worked in the mean time, till the ſcoria paſſes: but no freſh coals ſhould be longer added. Sprinkle then the exterior veſſel, formed of lute and coal to receive the metal, in order to cool the lead, which will be collected in it: and examine the ſcoria, to diſcover, whether there be any grains of metal interſperſed in it; and, if there be, pound it; and waſh off the light part, that the lead may be ſeparated.

OBSERVATION.

The ores of copper, tin, and iron, admit of being treated in the ſame way, with the alteration of the circumſtances below ſhewn: which the particular properties of each render requiſite.

In the caſe of copper, the perforation of the pedeſtal, which makes the communication betwixt the melting pot, and the exterior veſſel to receive the melted metal, muſt be firſt ſtopt up with a round piece of coal, plaſtered over with lute: and the heat muſt be made much greater, by pointing the nozzle of the bellows obliquely, that the flame may be driven to the ſurface of the melting pot; and continued, till all the metal be run together into it: and then it muſt be examined by means of the fire hook or poker introduced into the melting pot through the middle opening of the pedeſtal, whether the contents be in perfect liquefaction; or whether any of the ſcoria appears of a tenacious pitch-like conſiſtence: which, if found, it muſt be taken out by the ſame opening, to prevent its obſtructing the paſſage of the metal to the exterior veſſel made to receive it. When every thing is thus rightly adjuſted, the perforation, ſtopt up by the coal and lute, muſt be opened, by means of an iron rod made ſharp at one end, that the metal may run out into the veſſel deſigned for that end: but, if there be more ore to be wrought, the perforation and paſſage muſt be cleared from any ſcoria, and ſmall coals; and again ſtopt as before. But, in the caſe of braſs, no attempt ſhould be made to cool it, by ſprinkling with water: for this metal is ſo impatient of aqueous moiſture, that, even when it is ſo cooled as to attain a ſolid form, it flies with great violence on the contact of any humidity.

The ore of tin may be treated in the ſame manner as that of lead, after it is duly prepared: but the bellows need not point ſo much towards the melting pot, nor be worked ſo ſtrongly; and the coal ſhould be of ſofter wood; and in leſs pieces; that the heat may be the more quickly excited to the proper degree; and the ſooner ſpent again: if they be ſprinkled with water, and even the ore, alſo, they will, for a ſhort time, ſupport a fire ſufficiently ſtrong.

If iron ore be treated experimentally in this manner, it ſhould undergo a thorough previous uſtulation: and, if it appear yet to abound in mineral ſulphur, ſome pounded lime ſtone ſhould be mixed with it. The heat required is, alſo, the greateſt that can be produced: in order to which, larger, and ſmaller pieces of coal ſhould be mixt together; and the veſſel receiving the metal, ſhould be, likewiſe, kept heated of a luminous degree, by coals ſurrounding it: care being taken, that the paſſage leading into it be not ſtopt up by them. It is by ſimilar means that iron ore is, for the moſt part, treated in our country, in order to its firſt ſeparation from the other heterogeneous matter combined with it in the ore: but other ſubſequent means are neceſſary, as was before obſerved, to bring it to a malleable ſtate.

Operations founded on the ſame principle are, likewiſe, practiſed for the extraction of copper, and tin, from their ores in ſome caſes.

EXPERIMENT VI.

Fuſion of metallic bodies. See the rules given on the general operation of fuſion, page 206.

EXPERIMENT VII.

Calcination of metallic bodies by calefaction.

When iron and copper are to be calcined, take them in the ſtate of filings; and expoſing them, being ſpread on a tile, to a luminous degree of heat, but leſs than will melt them, they will be reduced to a calceous ſtate: the iron aſſuming a red or purpliſh colour, according to the degree of heat: and the copper a bluiſh or blackiſh purple.

When lead or tin are to be calcined, melt them in a teſt, or any other ſhallow veſſel, where there may be a large ſurface expoſed to the fire. The metals will gradually loſe their ſpecific appearance: the part calcined aſſuming a pulverulentous form: which, being taken off from time to time, the whole will at length be reduced to the ſame ſtate. The lead will be, by ſuch means, converted into a red powder, if the calcination be perfect: and the tin into a white.

When zinc, biſumth, and arſenic, are to be calcined, it muſt be performed by ſublimation; for that degree of heat, which decompounds them, renders them volatile: and their calces muſt, therefore, be obtained in the ſtate of flowers: which, when pure, will be white in the caſe of all theſe three ſemi-metals.

Antimony may be calcined by the continuation of the operation directed for the uſtulation in Experiment III. Sect. I. Chap. II. Part V.

Mercury is calcined by continuing it, for a great length of time, with an expanded ſurface, to a degree of heat that will not raiſe it in vapour: the produce is a red powder.

OBSERVATION.

Gold and ſilver, as has been before obſerved, admit of no calcination; being perfect metals: and the ſame holds good of platina; which, though only an anomalous metallic body, agrees with the perfect metals in this point.

The calcination of iron, and copper, is ſeldom performed, but for the preparation of colours for painting in enamel, or on glaſs. Lead and tin are more frequently calcined, the firſt in large works for the production of *minium*, or red lead, as the calx is called: the other by perſons who make it their buſineſs alſo; and who ſell the calx of tin, prepared by ſimilar means, under the name of *putty*, to lapidaries, and other workmen; who uſe it for poliſhing, or for making a white colour for enamel. Zinc is not calcined with any commercial intention; but the flowers of biſmuth are prepared as a fucus. Antimony is calcined, in order to its being vitrified; the glaſs being uſed in medicine. Mercury is, alſo, calcined for the ſame purpoſe; the red powder being moſt generally called *precipitate per ſe*: but more accurately, according to the college of London, *mercurius calcinatus*.

EXPERIMENT VIII.

Calcination of metallic bodies by detonation with nitre; exemplified in the caſe of tin.

Take filings of tin, and nitre, groſsly powdered, equal parts; and mix them well together. Then, having put a crucible, or any other melting pot, into the fire, and ſuffered it to grow of a luminous degree of heat, throw in the mixture of the tin, and nitre, by a ſpoonful at a time: allowing a ſufficient interval for the exploſive effervеſcence, excited by each quantity, to ceaſe, before it be ſucceeded by another. When the whole is thus put into the crucible, and no further appearance of detonation remains, take it out of the fire; and pour the contents into boiling water; and, breaking the crucible, put the pieces of it, to which any part of the calcined matter adheres, being firſt well cleanſed from the coals or aſhes of the fire adhering to it, alſo into water. The lixiviate ſalt formed by the decompoſition of the nitre, of which the acid will have been ſeparated by the phlogiſton of the tin, being, by this means, diſſolved by the water, the calx of the tin will be found remaining.

OBSERVATION.

In the ſame manner, copper, lead, iron, zinc, and regulus of antimony, may be calcined: as, alſo, biſmuth; but it requires a longer time to the calcination of that ſemimetal;

metal: in which the phlogiſton is either leſs in quantity, or in ſuch a reluctant ſtate, in relation to combination with the nitreous acid, that no ſenſible detonation, or efferveſcence, enſues; and the mixture may, therefore, be thrown all together into the crucible at firſt.

This method of calcination is rarely put in practice on any metallic body in its ſimple ſtate, unleſs in the caſe of antimony, for the preparation of the medicine called *diaphoretic antimony*; or of the *modern fever powder*: though it is a very quick, and more effectual manner of preparing the calces of metallic bodies; eſpecially that of tin for enamel painting. On the compoſitions of other metallic bodies with a ſmall proportion of gold or ſilver, it is ſometimes practiſed for their ſeparation: as, by the deſtruction of the other metallic bodies by the action of the acid of the nitre on their phlogiſton, which has no effect on thoſe perfect metals, a decompoſition is made: the gold or ſilver being collected in a metalline form, eaſy to be ſeparated from the calx of the other metallic bodies.

EXPERIMENT IX.

Reduction of metallic bodies from their calces to their proper metalline form, by reſtoration of their phlogiſton, through the means of cementation with the coal of animal or vegetable ſubſtances.

Take the calx of the metallic body to be reduced; and mix it well, by grinding them together, with half their weight of the coal of any animal or vegetable ſubſtance; and, having put them into a crucible covered by a proper lid, or by inverting another that is leſs into it, place it in any fire where it may undergo a degree of heat ſufficient to fuſe the metal. After it has continued ſome little time in ſuch heat, take it off the fire: and, ſetting it on any ſtone or brick pavement, ſtrike it immediately with a hammer; that the reduced metal may run together: which, on examination after the whole is grown cold, will be found in a maſs, in its proper metalline form, at the bottom of the crucible.

OBSERVATION.

If the metallic calx be corroded, or any way combined, with acid, it is proper to mix a third part of its weight of black flux, or, in default of that, of lixiviate ſalt, with the charcoal, in order to ſeparate ſuch acid from the calx; and in the caſe of lead or tin, tallow or pitch, mixt with the calx, will anſwer the ſame end as the coal. In the caſe of iron the reduction may be, as was before obſerved, made with a much leſs degree of heat than will melt that metal. But the reduced iron will not, nevertheleſs, by ſuch treatment, be brought into a reguline maſs with a metalline appearance; but remain in a pulverulentous form; though actually brought back, in all other regards, to its true metallic ſtate.

In the caſe of the arſenic, which is rendered volatile by leſs heat than will fuſe it, the reduction may be beſt performed in this manner. Add one part of the black flux, to two of the chryſtalline arſenic; which is, with reſpect to its metallic nature, in a calcined ſtate; though it is far from agreeing with the calces of other metallic bodies in its general properties: and mix them thoroughly well, by grinding them together. Let a ſtrong fire be then prepared; and put a crucible into it, that it may grow nearly red hot: at which time, thruſt into it the mixture of arſenic and flux, incloſed in paper of ſeveral folds thickneſs: and cover it ſtantly with a lid, or a leſſer crucible inverted upon it. Give it then a quick heat: and, when it may be judged that the crucible has attained the full proportion of heat that degree of fire will impart to it, take it out; and let it remain till it be cold: at which time, ſuch part of the arſenic, as was not diſſipated in fumes in the operation, will be found in a reguline ſtate. The proceſs may be, otherwiſe, performed, with much greater ſucceſs, with reſpect to the proportion of regulus of arſenic obtained, in the way of ſublimation; by joining one of the earthen veſſels called *long-necks*, containing the mixture, to a glaſs receiver; and fixing the long-neck horizontally in the fire, ſo that the arſenic may be ſublimed into the receiver, which will be at the outſide of the furnace; and there condenſed: in which caſe it will, notwithſtanding the ſublimation, aſſume a ſemi-metallic form, if not too diffuſely ſpread on the ſurface of the receiver. Or, in default of a long-neck, this operation may be performed by a glaſs body luted and fitted to the receiver, in the place of ſuch long-neck. It is uſual to add iron to the arſenic in the reduction: but, by ſuch treatment, the regulus becomes impure: and the experiment is not equally concluſive, with reſpect to the metallic nature of the arſenic.

Zinc, being perfectly calcined, does not admit of reduction by any means at preſent known.

EXPERIMENT X.

Combination of metallic bodies with each other by fuſion.

This is performed in general by the ſimple fuſion of the metallic bodies with each other: and, if the operation require a greater length of time, or thoſe metallic ſubſtances that quickly calcine are to be combined with thoſe which require a ſtrong heat to their liquefaction, ſuet, pitch, or ſome other reducent ſubſtance, ſhould be added, as ſoon as the whole matter be perfectly melted: which being then well ſtirred together by a cold iron rod, muſt be immediately poured out.

OBSERVATION.

In this manner, all ſuch metallic bodies as admit of fuſion may be combined together: and zinc may, alſo, be combined with copper by cementation, as there will be occaſion to ſhew below: and arſenic with all the metals, by expoſing them, when of a luminous heat, to the fumes of it.

EXPERIMENT XI.

Combination of metals with mineral ſulphur.

Take any metallic body (except gold and platina), in the ſtate of filings; and mix it thoroughly well with an equal weight of mineral ſulphur. Put the mixture into a crucible; and, having covered it, place it on the fire; and give it a degree of heat, in proportion to the quicker or ſlower tendency of the ſubject metallic body to fuſion: but much leſs will ſuffice in the caſe of copper, or iron, than will bring them to liquefaction alone. After the matter has undergone the action of the due heat for ſome time, take the crucible out of the fire; and the metal will be found combined with the ſulphur, forming a ſort of ſpeciouſly reguline maſs: of which the appearance will vary, according to the kind of metallic body ſubmitted to the operation.

In the caſe of mercury, it is proper only to fuſe the ſulphur; and to add the mercury, previouſly made of a moderate degree of heat, gradually to it: taking care, if it catch fire, to cover it inſtantly with a wet cloth.---Or this combination may be made, by triturating the mercury and ſulphur well together; by which means, the compound will take the form of a black powder, that is called *Æthiops mineralis* in medicine. But the combination of mercury and ſulphur is not, by either of theſe methods, rendered ſo perfect; as by a ſubſequent ſublimation.

OBSERVATION.

The mineral ſulphur cannot be again ſeparated from the metallic bodies, with which it is thus combined, by any method general to the whole number: but various means are required to be perſued, according to their diverſe nature.

In the caſe of the metals, as they are more fixt, uſtulation, (as before directed in Experiment III. Sect. I. Chap. II. Part V. in the caſe of ores,) till no more ſulphur can be ſeparated, muſt be previouſly uſed: and the metal may then be fuſed, firſt with lixiviate ſalt, and ſome ſmall proportion of nitre; and then with the black flux. Antimony, zinc, and biſmuth, may, after a ſlighter uſtulation, be freed from the ſulphur, by the means below directed for the ſeparation of the reguline part from the crude antimony: which is, in fact, only ſuch reguline part, combined with mineral ſulphur in a certain proportion. Arſenic may be freed from ſulphur by repeated ſublimation, after the previous commixture of lixiviate ſalt: in order to the moſt effectual performance of which, the arſenic, being levigated to a very fine powder with ſome proportion of lixiviate ſalt, ſhould be ſprinkled with a ſeparate ſolution of the ſame, and the ſublimation may be performed, as was directed in the obſervation on the preceding experiment; avoiding only to fix the receiver to the long neck, till the moiſture of the ſolution be well exhaled. Some of the metallic bodies may be, likewiſe, departed from mineral ſulphur by means of each other, according to their ſuperior degrees of attraction: as arſenic by mercury; and mercury by iron: a ſubſequent ſublimation being inſtituted, to their actual ſeparation after the departure.

This operation is ſeldom performed on copper, or iron; unleſs ſometimes in order to the calcination of them for colours in enamel painting: but arſenic and mercury are more frequently treated in this manner; the firſt to produce the factitious orpiment, called *king's yellow*, for the purpoſes of painting: and the latter to produce *Æthiops mineralis*, or *factitious cinnabar*, for medicinal uſes; and *vermilion*, for painting; vermilion being, in fact, cinnabar finely levigated.

EXPERIMENT XII.

Combination of metallic bodies with hepar ſulphuris.

Take lixiviate ſalt, and mineral ſulphur, equal parts; and, having put them into a crucible, ſet them in a moderate heat; and ſtir them till they be perfectly liquefied and mixed together; and form the hepar ſulphuris. While they remain thus in a fuſed ſtate, add any metallic body, in the ſtate of filings, or thin plates, in any proportion not exceeding one third part of the hepar ſulphuris: and augment the heat, but not in a very great degree. The metallic body will be ſoon combined with the hepar ſulphuris: and will form a maſs not the leaſt ſimilar in appearance to metallic bodies.

OBSERVATION.

Gold, and platina, being thus combined with hepar ſulphuris, the compound will be wholly ſoluble in water, ſo as to paſs the filter: but, in the caſe of the other metallic bodies, on the ſolution of the hepar ſulphuris by water, they are departed: and precipitating, form a magiſtery; by which means a reſeparation is obtained. But as this does not extend to gold and platina, other means muſt be uſed to free them from hepar ſulphuris: the moſt expedite method of which is uſtulation, with the acceſs of air: as by that means the mineral ſulphur is deſtroyed, and the metal again ſet at liberty.

This proceſs is rarely practiſed but for experiment: in which view, it is of conſequence, in ſhewing the unfitneſs of uſing alkaline ſalts as a flux in the reduction of ores replete with mineral ſulphur: as hepar ſulphuris being by ſuch means produced, it neceſſarily combines with the metallic part of the ore; and mixes ſome part of it with the ſcoria.

Stahl, who firſt publiſhed the proceſs for diſſolving gold in this manner, gives a reaſon of a very whimſical kind, for the experiments he made with relation to it. For he ſays, he was induced to perſue them from a curioſity to diſcover the method, by which Moſes might, without a miracle, burn the golden calf; afterwards reduce it to powder; and at laſt render it potable: all which he imagines might be effected by the combining it with hepar ſulphuris.

EXPERIMENT XIII.

Combination of metallic bodies with liviviate ſalt, and the fixt ſulphur of the coal of animal ſubſtances.

Take lixiviate ſalt; and, having mixt it with twice its weight of the coal of blood, ſubject them together, in a covered crucible, to ſtrong heat. After they have remained in that ſtate, till the flame, which will at firſt be a ſtrong yellow or white, becomes ſlender and blue, throw the matter out of the crucible into boiling water; and, breaking it, ſo that it may be well mixt with the water, boil it for ſome time; and then filter it. Reduce the filtered lixivium, afterwards, by evaporation, to ſuch degree of ſtrength, that there may be only four times the weight of the lixiviate ſalt. To this lixivium, while in a boiling ſtate, add the magiſtery of gold, ſilver, mercury, biſmuth, or zinc, precipitated by the addition of lixiviate ſalt, from their proper acid menſtrua; and well waſhed: but the proportion muſt not exceed one fourth of the ſalt forming the lixivium. Continue then the boiling, till the metallic body be diſſolved: which will remain ſuſpended in the fluid, when cold, in ſuch manner, that the whole will paſs the filter.

OBSERVATION.

This experiment is delivered on the authority of German writers of very great credit: but I cannot be poſitive as to the certainty of it, on my own knowledge with reſpect to all the metallic bodies here enumerated: they may however be reſeparated by the addition of any acid. The proceſs of this experiment has not been hitherto applied to any practical purpoſe in chemiſtry, as far as I am informed; and is not, in general, known in our country.

EXPERIMENT XIV.

Combination of metallic bodies with the ſolution of lixiviate ſalts.

Take lixiviate ſalt, one part; and water four. Boil them together; and add to them, while boiling, the magiſtery of copper, lead, tin, or iron; regulus of antimony in its intire ſtate; and arſenic powdered: and continue the boiling till the metallic body be diſſolved.

OBSERVATION.

This proceſs is delivered on the ſame authority with the preceding: and is not hitherto introduced into uſe.

EXPERIMENT XV.

Combination of metallic bodies with volatile alkaline ſalts.

Take volatile ſpirit (or more properly a ſolution of volatile alkaline ſalt in water) impregnated to the degree of ſaturation, and add to it the magiſtery of gold, ſilver, copper, iron, biſmuth, zinc, lead, or mercury. Digeſt them in a proper circulating veſſel with as great a degree of heat as may be adminiſtered without ſubliming the ſalt: and let them continue in that ſtate till the metallic body be combined: the magiſtery of lead will not however be perfectly diſſolved, but will form a white thick mucilage.

OBSER-

OBSERVATION.

The credit of this experiment ſtands on the ſame baſis as the two foregoing: and thoſe who would be more particularly informed with reſpect to it, may conſult *The hiſtory of the Academy of Sciences at Berlin*, anno 1745: POTTII OBSERVAT: *collect.* 2. p. 37: and KURELLA *Chemiſche erfahrungen*, p. 24. T. I. The ſolution of the ſal ſaponarius, or the volatile alkaline ſpirit prepared with lime, promiſe much more to have this power, than the ſimple ſolution of lixiviate, or volatile alkaline ſalts.

EXPERIMENT XVI.

Combination of metallic bodies with acids:

See Experiment XXII. Sect. III. Part II. Vol. I. for the formation of metallic neutral ſalts.

EXPERIMENT XVII.

Departure, with a conſequent precipitation, of metallic bodies from acids, by each other; or by the addition of alkaline earths or ſalts.

Take any ſolution of a metallic body, in any acid; and let other metallic bodies, in the ſtate of thin plates, or filings,---or any alkaline ſalts, or earths, that will combine with the reſpective acid, by which the ſolution was made,---be added according to their degree of attraction, as laid down in the table of acids and alkalies, p. 273. Vol. I: and the metallic body will be departed, and ſubſide in form of a magiſtery; in ſome caſes, with a metalline appearance; and in others of various colours.

The alkaline ſalts ſhould be uſed in a diſſolved ſtate: and care ſhould be taken, that more be not added than is barely ſufficient to balance the acid combined with the metallic bodies.

OBSERVATION.

This operation is practiſed on various occaſions. The ſolutions of gold and ſilver are precipitated by copper in ſome proceſſes for their purification; and the copper is, afterwards, precipitated by chalk, for the obtaining verditer, which is uſed as a pigment in painting. When gold is precipitated by copper, it reaſſumes its proper colour, and metalline appearance; but when departed from the acid by alkaline ſalts, tin or mercury, it has a red or purple colour; and by the firſt a fulminating quality, alſo; as will be ſhewn below. Biſmuth is, likewiſe, precipitated from acids by lixiviate ſalt, in order to procure the magiſtery; which, being extremely white, is uſed as a dry fucus by the Portugueſe and Spaniſh ladies; who are, at preſent, followed by ſeveral in our own country in this practice.

SECTION II.

Experiments on particular metals; and obſervations on them.

EXPERIMENT I.

Demonſtration of the incombuſtibility of gold; and of its fixity in every degree of heat producible by art.

TAKE pure gold; and, having put them in a teſt, place it in a furnace; and give the ſtrongeſt degree of heat to it, that can be produced either by draught or blaſt: and continue it in this heat, for any length of time:—Or take gold, in filings, or granulated; and mix with it nitre; ſubjecting it, afterwards, to any degree of heat;—Or take a ſmall grain of gold;

and, laying it on a piece of unglazed porcelain, place it in the focus of the largeſt concave mirror, or any other burning glaſs:— and, in all theſe ſeveral caſes, the gold will be only fuſed, without being decompounded, ſublimed, vitrified, or any otherwiſe changed, or diminiſhed in quantity, by the heat or fire. Neither the duration of the culinary fire, the force of the focal heat, nor the combuſtive action of the nitre, having any power with reſpect to gold, when it is in a perfectly pure ſtate.

OBSERVATION.

The fixity of gold, with its invitrifiability, under every degree of heat producible on the principle of culinary fire, has been always well known: but the relation of the event of ſome experiments, made by Mr. Homberg, had induced moſt of the writers after him to aſſert, that gold could be ſublimed and vitrified per ſe, by the focal heat of large burning glaſſes. But the defective inaccurate manner, in which he ſeems to have made the experiment, according to his own relation, ſeveral circumſtances wanting to render them concluſive being omitted, firſt gave reaſon to doubt of the fact, he would have evinced by them; and the repeated trials of many other able perſons, with even more powerful glaſſes than what he employed, without any ſingle inſtance of a ſimilar effect, where the experiment was conducted with due ſkill and care, render his authority, at preſent, of no weight with relation to this point: and give a juſt foundation to the contrary poſition, that gold cannot be otherwiſe changed by any action of heat or fire, while pure and unmixt, than by being brought to a ſtate of liquefaction.

It is not, however, to be concluded, from its unchangeableneſs by heat, that gold is a ſimple elementary body. For the fulminating qualities of the magiſtery produced according to the proceſs of the next experiment; which is capable of an amazingly ſtrong exploſion in conſequence of an intimate commixture of the gold with nitrous ſalts; as, likewiſe, its ſuſceptibility of change of colour by acids, and alkalies, in a manner ſtrictly analogous to the tinging gums and reſins of vegetables; plainly evince, that it contains phlogiſton in a copious degree. The neceſſity of the preſence of ſome earth to the conſolidating phlogiſton, according to univerſal analogy, gives likewiſe the juſteſt ground of preſumption, that gold does not vary from the imperfect metals, or other metallic bodies, in this particular: but only, that the phlogiſton is combined with the earth in ſuch manner, as checks, both its volatility, and that commenſtruative action with the nitrous acid on which combuſtion depends, unleſs under certain peculiar circumſtances.

EXPERIMENT II.

Separation of gold from the other mineral ſubſtances, (except ſilver and platina,) combined with it, either in the ſtate of ore, or in any other manner where the proportion is not great, by ſcorification, and cupellation.

The ore being prepared by elutriation and uſtulation, (as before deſcribed,) where it appears to abound in ſulphur, muſt be reduced to powder; and eight times its weight of lead muſt be procured in the ſtate of filings or granulated: as, alſo, a teſt, ſuch as thoſe of which the fabrication is taught p. 110. Vol. I., in the condition there directed. One half of the lead muſt then be laid on the teſt; and ſpread equally on its interior ſurface; and the ore muſt be laid on the part of the lead, ſo ſpread; and covered with the other part. The teſt thus charged with the lead, and ore, muſt be placed at the further end of a muffle put into the aſſaying furnace, of which the conſtruction is given p. 143. Vol. I. prepared as directed in p. 148. The fire muſt be then lighted;

and increaſed by degrees, till the lead boil in the teſt; and, when it is perceived by inſpection through the aperture of the furnace, that the ore, which will at firſt float on the ſurface of the melted lead, but afterwards grows ſoft, and fuſes, is thrown towards the ſides of the teſt, that which is left bare in the middle appearing to boil and emit fumes, the fire muſt be checked, ſo that there may ſcarcely be any ebullition at all for about a quarter of an hour. After this let the heat be again raiſed; and the ſhining ſurface of the lead will gradually appear dull, and be covered with *ſcoriæ*. Stir the matter then, to the middle, by an iron rod bent at the point; and draw all the pulverulentous part, which may float on the ſurface, towards the ſides; that any remaining portion of the ore may be diſſolved. When the whole is perfectly fuſed, and has ſufficiently undergone the action of the fire, which may be known by its dropping from the rod when dipt into it, and leaving a thin ſhining coat at the extremity of that part which was immerſt, take the teſt out of the

the fire; and pour the contents into an iron mold prepared of due magnitude for that end; and previouſly heated, and greaſed with tallow: and, when the whole is ſufficiently cold, divide the regulus from the ſcoria, by the ſtroke of a hammer: powdering the ſcoria, likewiſe, and ſeparating from it ſuch parts, as, being of a metalline texture, reſiſt the comminution; and adding them to the regulus.

Prepare then a cupel, made according to the directions given p. 102. Vol. I; and of ſuch magnitude, as to be at leaſt of half the weight of the regulus intended to be put into it: and, having placed it in the furnace; for the doing which, inſtructions are given p. 148. Vol. I.; burn it, as the materials of which it is formed may require. The regulus being in the mean time formed into thin plates, and freed from any *ſcorious* parts adhering to it, by beating it with a flat hammer, muſt now be put into the cupel, by means of a ſmall pair of tongs, being firſt wrapt up in a piece of paper; and the fire muſt be raiſed, ſo that the lead may boil and fume: but not in a greater degree than will admit of the cupel's being plainly ſeen. The lead will, by this means, be vitrified; and, being moved to the ſides of the cupel, will be abſorbed by it. But if the ebullition be violent, and the fumes in a very great quantity, the fire muſt be lowered by cloſing the apertures of the furnace, to check the draught of air. Increaſe the fire, nevertheleſs, as the lead diminiſhes in quantity, by its being vitrified, and abſorbed by the ſubſtance of the cupel; till, at length, a vivid combination of colours, reſembling ſmall rainbows, interſecting each other in many different directions, are ſeen on the ſurface of the metal; and terminate at laſt in ſuddenly diſplaying the gold, that was before obſcured by the lead in its calcined ſtate previous to its vitrification, to the ſight; with the appearance either of a ſhining yellow colour, or of a bead of fire; according to the degree of heat maintained in the furnace of that point of time. The cupel muſt be, nevertheleſs, ſtill left a minute under the muffle: and then gently drawn, by the bended iron rod, towards the door of the furnace: and when the gold is ſo cooled, as to be of a ſolid conſiſtence, the cupel may be taken from under the muffle, by the ſmall tongs: and, in its cavity, the gold will be found of a globular form, with the lower part unequal, and full of ſmall holes: and, on proper examination, will be found nearly pure, unleſs combined with ſilver or platina.

OBSERVATION.

The principle, on which this proceſs is founded, is the vitrifactive power of lead, with reſpect to the metallic, or other mineral bodies, that may be commixt with gold, except ſilver and platina; by which they are firſt converted, together with the lead, to glaſs; and then abſorbed by the ſubſtance of the cupel; which is, in that view, fabricated of a looſe and porous texture; leaving the gold almoſt in a pure ſtate, except with relation to ſilver, or platina, or unleſs there were ſuch a proportion of copper, that the quantity of lead employed was not ſufficient to vitriſy it.

This proceſs is conſtantly practiſed for the ſeparation of metallic, or other bodies, combined with gold in its mineral ſtate, or by any artificial commixture: and it is made ſubſervient, as well to the more accurate freeing of gold, from other metallic bodies in the intention of *an aſſay*, or examination of the exact quantity of gold contained in any compound; as to the purification of gold, in large, for commercial purpoſes. The method delivered in this experiment, is not, however, ſimply in all caſes ſufficient to this end: for gold is, ſometimes, found commixt with other mineral bodies, either in ſuch proportion that the quantity of lead, here directed, is not ſufficient to ſcorify the whole; or they may be of ſuch nature, that the lead has not the power of ſcorifying them as in the firſt operation of this proceſs, or vitrifying them as in the ſecond: but either a greater quantity of lead is required; or ſome previous preparation, in order to diſpoſe the otherwiſe refractory matter to ſubmit to the power of the lead. Or, in ſome caſes, the gold itſelf may be in ſuch a ſtate, that it may combine with the ſcoria.

In the caſe of ores rendered refractory by lapidaceous earths, not to be ſeparated by elutriation, glaſs of lead ſhould be added, in the proportion of an equal weight to that of the ore: and the quantity of granulated lead ſhould be increaſed to twelve times its weight. The fire muſt, alſo, be correſpondently managed with reſpect to its duration and ſtrength.

In the caſe of gold combined with iron, which, in its metallic ſtate, does not yield to the vitrifactive power of lead, a ſolution of the mixt metallic maſs in oil of vitriol, and a ſubſequent calcination, are moſt advantageouſly practiſed: or a precipitation of the gold from the iron may be made, by bringing the metal to the ſtate of filings; and keeping it in fuſion, in a cloſe veſſel, with twice its weight of antimony for a quarter of an hour: after which, being grown cold, and the ſcoria taken away, the antimony in the precipitated regulus muſt be deſtroyed by ſcorification, without addition; the cupellation being, afterwards, performed, as here directed, with the addition of the lead.

In the caſe of gold, commixt with tin, a calcination with the addition of double the weight of lead, is the moſt effectual preparation: which calcination is ſoon performed in a moderate degree of heat: and, in the ſubſequent ſcorification, the quantity of lead ſhould be at leaſt ten times the weight of the remaining metal.

The ſcorification in this proceſs may, in default of a teſt, be performed in a ſound crucible, that will hold three times the quantity of the matter to be put into it: an addition being made, beſides that of the lead, of as much ſand-over and common ſalt, as being liquefied, will occupy the ſpace of half an inch in the crucible; and, if much ſulphur be contained in the mineral compound, ſubjected to the operation, a half part of the filings of iron, free from ruſt, ſhould be ſubjoined. The crucible, thus charged, and well cloſed with a lid, ſhould be put into any furnace; and ſurrounded, to its upper edge, with coals; which, being kindled, muſt be ſuffered to burn, ſo as to melt the whole matter in the crucible: for which a moderate degree of heat will ſuffice. Things being continued in this ſtate for a quarter of an hour, the cover of the crucible muſt be taken off; and the matter, being ſtirred with an iron rod, muſt be ſoon after, either poured into a greaſed mold of the funnel form, or ſuffered to remain in the crucible till cold; and, if the regulus be found in a due ſtate, committed to the cupel after the ſeparation of the ſcoria.

In the compounds of gold with metallic bodies, that reſiſt the fluxing and vitrifying power of lead unaſſiſted, the ſeparation may be thus made. Take of black flux double the weight of the metallic compound in queſtion; and equal its weight of pearl-aſhes: and, having put them, with the alloyed gold, into a crucible, which will hold four times the quantity of matter, cover it with a lid; and give a ſufficient heat to fuſe the contents. Uncover then the crucible; and add, by repeated injections, the due quantity of granulated lead; beginning at firſt with a little: which quantity muſt be diſcretionally regulated by the proportion, and nature, of the other metallic matter, combined with the gold: copper requiring the moſt; which, however, need not, in any caſe, exceed twelve times the weight of the ſubject matter of the operation. When all the lead is commixt; and well liquefied, let the fuſed matter be well ſtirred by an iron rod; and then poured into a funnel-ſhaped mold, to be treated as in the other caſes.

In the common purification of gold from copper or lead, one operation is made to ſerve; and the lead is added at ſeveral different times: and, the apparatus being proportionably inlarged, a great quantity is cupelled together. This operation is, alſo, performed, on a proper hearth, with the blaſt of bellows: a hollow being ſunk into the hearth, to contain the teſt ſurrounded with coals, in ſuch manner, that its upper edge ſhall not project beyond the level of the hearth: and iron plates are ſo fixt, near the nozzle of the bellows, that the blaſt may be determined full upon the teſt.

EXPERIMENT III.

Depuration of impure gold, by the combuſtive action of nitre on the imperfect metals, or other metallic bodies, combined with it.

Beat the impure gold into thin plates; and, having cut them into ſmall pieces, put them into a crucible with a fourth part of their weight of powdered nitre; with which is commixt, half the ſame quantity of pearl-aſhes; and about a ſixth part of powdered glaſs. Cover the crucible, thus charged, with another leſſer one inverted into it; but previouſly perforated with a hole in the bottom, as big as a pea; and lute the puncture of the crucibles; leaving, neverthelefs, the hole open. Having placed them in any furnace, and ſurrounded the lower crucible with coals to its upper edge, kindle the fire; and raiſe it to a degree ſufficient to fuſe the gold. Then hold a piece of coal a finger's length high over the hole, in the upper crucible: and, if a gleam of light appear on and around it, attended with a low hiſsing in the cavity of the crucible, it may be concluded, that the fire is of the due degree: but, if theſe appearances be wanting, or only languidly produced, the fire muſt be augmented: or if, on the contrary, a ſtrong blaſt ſeem to iſſue from the hole, with a loud crepitation, it muſt be diminiſhed; as, otherwiſe, a large proportion of the gold would be blown out. When theſe appearances ceaſe, increaſe the fire; that the ſilver may be perfectly fuſed, and free itſelf from the ſcoria; and then take the crucibles out of the fire; in the bottom of the lower of which, when broken, after it is grown cold, will be found, the gold in a reguline and pure ſtate (except it contained ſilver or platina); and the ſcoria above it. Some ſmall part of the other metallic bodies will yet in moſt caſes remain in the gold: and, if it is to be rendered extremely pure, the operation muſt be repeated.

OBSERVATION.

By this means, gold may be freed from any other metallic body combined with it, except ſilver and platina, ſuch metallic body being deprived of its phlogiſton, by the commenſtruative action it exerciſes with the acid of the nitre; and brought firſt to the ſtate of a calx, and, afterwards, vitrified in a greater or leſs degree, according to the continuance of the heat, by the action of the ſalt formed by the decompoſition of the nitre; and by the glaſs, originally ſuperadded; the uſe of both which, is to check the too rapid action of the nitre on the metallic body; which would, otherwiſe, blow out a part of the gold. For this reaſon the operation cannot, however, be practiſed without loſs, where the proportion of the other metallic bodies is large to that of the gold: as the exploſion from the increaſed quantity of nitre, neceſſarily cauſes ſo violent an exploſion. The method, therefore, is much ſeldomer uſed than the preceding, on account of its being ſubject to that diſadvantage: and the difficulty of bringing the gold, in ſome caſes, to its proper malleable ſtate, without repeating the operation a great number of times.

EXPERIMENT IV.

Solution of gold in aqua regia.

Take any quantity of ſpirit of nitre; and, having put it into a retort, add to it half its weight of common ſalt previouſly dried. Diſtil them in a ſtrong ſand heat to dryneſs.—Or add, without a ſubſequent diſtillation, a fourth part of clean ſal Ammoniacus, powdered, to the ſpirit, by ſlow degrees, to avoid the effects of a too great ebullition. The ſame proportion of ſpirit of ſalt may, otherwiſe, be ſubſtituted; if to be obtained pure: but as it is now univerſally prepared by departure through oil of vitriol; and is in ſuch caſe ſcarcely ever free from that acid, which wholly depraves aqua regia; the uſe of the ſal Ammoniacus is much preferable.

To the aqua regia ſo prepared, and contained in a tall glaſs body, put thin plates of gold in any proportion, not exceeding one half of the weight of the aqua regia; and place the body in a ſand heat; covering the mouth with a cone of paper; and there let it remain, till the gold be perfectly diſſolved.

OBSERVATION.

This operation is practiſed moſt frequently for the ſeparation of gold and ſilver from each other, when the gold is in more than a triple proportion in the compound than the ſilver. In order to which, the ſolution, being made as directed in this experiment, muſt be poured off from the ſilver: which will be, in the form of a precipitated powder, in the bottom of the retort: and the precipitated matter muſt be waſhed, with ſome freſh quantity of the aqua regia, and, where great accuracy is required, afterwards by that weaker part of the ſpirit of ſalt which riſes firſt in the preparation of it; all which ſhould be added to the ſolution; that will then contain the whole quantity of gold which was in the compound. The ſolution of gold is, likewiſe, made in this manner, in order to the preparation of the calx Caſſii, for painting in enamel or on glaſs, (in the manner ſhewn in the obſervation on the next experiment): and alſo for that of the aurum fulminans, for ſpeculative purpoſes.

EXPERIMENT V.

Precipitation of gold from aqua regia, by alkaline ſalts, or metallic bodies; exemplified in the inſtance of the lixiviate ſalt.

Take the ſolution of gold, as prepared in the preceding experiment; and add to it, gradually, a ſolution of lixiviate ſalt in water, ſo long as any effervеſcence appears to follow on the further admixture. The gold will, by this means, be precipitated in the form of a magiſtery, of a reddiſh purple colour: which, being ſeparated by decantation of the ſupernatant fluid, is the *aurum fulminans*.

OBSERVATION.

In like manner, gold may be precipitated by the addition of volatile alkaline ſalts; or of any of thoſe earths, or metallic bodies, that will commenſtruate with aqua regia; or even by ſolutions of the ſame metallic bodies, previouſly made in other acids; as the green or blue vitriols, ſolution of mercury in aqua fortis, or of tin in aqua regia: but the form of the magiſtery is various, with different bodies; as well metallic, as ſaline, and terrene; and as well, in their combined ſtate with acids, as added ſimply, or per ſe. All alkaline ſalts, and earths, precipitate it of a crimſon red, or of a purple colour: as do, alſo, tin, or mercury, either added in a ſimple ſtate, or combined with acids: but copper and iron in a ſimple ſtate precipitate it in a metallic form; though the powder is not bright, but of a browniſh yellow colour: and the ſame metals, combined with the vitriolic acid, precipitate it of a bright appearance, and intenſe yellow colour. The ſtate of the magiſtery of gold, with reſpect to its coloured or metalline appearance, does not, therefore, ariſe from any obvious cauſe, regarding the nature of the bodies, by which it is departed from the acid combined with it: nor is there any other account to be given of the reaſon of theſe variations, from any known principle: but it is certain, that they do not proceed from any other decompoſition the gold ſuffers in the operations: as it may be reduced again to its original ſtate, from that of any of theſe magiſteries, by ſimply ſeparating it from the ſalts, or acids, combined with it, and uniting the parts in one cohering maſs by fuſion; without ſupplying any matter to it, that may be ſuppoſed to have been ſeparated from it in the ſolution and precipitation.

This operation is rarely practiſed with alkaline ſalts; unleſs ſometimes with the lixiviate ſalt, for the production of the aurum fulminans, in an experimental view: but I have, nevertheleſs, known volatile alkaline ſalts uſed for the preparing the red magiſtery, in order to enamel painting: and, if an artiſt of ſome eminence,

nence, who learnt the art of enameling in this country, and though now reſident in France, and a gentleman of remarkable genius and knowledge, who aſſiſted him in the cultivation of this art, may be believed, the fineſt parcel of this red, that ever was produced, was prepared in this way. The precipitation with tin is much more frequently made, for the preparation of a red pigment for enamel, and ſtaining glaſs; which, by ſome of the German, and other writers after them, is called *calx Caſſii*; from ſome diſcoveries ſuppoſed to be made by one DR. CASSIUS reſpecting it. The method perſued for this end is, the one to put long pieces of tin into the ſolution of the gold in the aqua regia, and ſuffer them to lie there till no more gold appear to be precipitated; after which, the fluid ſhould be poured off; and the magiſtery of the gold waſhed and dried; but care muſt be taken, that the tin do not continue too long in the ſolution; for it will, when impregnated beyond a certain degree, be converted to a jelly-like ſubſtance: which is not to be ſeparated from the magiſtery without changing its nature. Another method, which may be practiſed with more certainty of ſucceſs, is, by uſing a ſolution of tin in aqua regia, inſtead of the crude tin: in which caſe, a ſmall quantity of the ſolution of gold ſhould be put into a large glaſs of water; and a little of the ſolution of tin added to it; which will, in a ſhort time, precipitate the gold: when other ſucceſſive quantities of the ſolutions ſhould in like manner be commixt with water, till the whole of the gold be precipitated. But the water in the glaſs ſhould be poured off from the magiſtery frequently; and freſh added; to prevent its being ſo loaded as to grow thick.

The precipitation of gold, by a ſolution of mercury in ſpirit of nitre, or of green or blue vitriol, is ſometimes practiſed for the recovery of gold from aqua regia, when the ſolution of it is made, in order to the ſeparation of the gold from ſilver. But that is more accurately done, with reſpect to the purity of the gold, by exhalation; and a ſubſequent fuſion in a crucible with borax, and a little nitre, and pearl aſhes.

EXPERIMENT VI.

Separation of gold from aqua regia, by the addition of æther, ſpirit of wine, and the more exalted ethereal oils.

Take a ſmall quantity of the ſolution of gold in aqua regia, as made in Experiment IV; and add to it, an equal bulk of æther; ſhaking them together. Let the mixture then ſtand at reſt; and there will appear a ſhining ſcum, or pellicle of gold; which will increaſe till the whole of the gold be ſeparated from the aqua regia; and then continue in that ſtate floating on the ſurface: the aqua regia loſing the high yellow colour, which the gold had imparted to it.

Strong alcohol, or any of the more exalted ethereal oils, being added to the ſolution, will produce the ſame effect: except that the gold will not continue ſuſpended; but, after ſome time, be precipitated to the bottom.

OBSERVATION.

The manner in which æther, and alcohol, or eſſential oils, act on the aqua regia, in the ſeparation of the gold, ſeems, by the difference of the effects, to depend on different principles. For the æther attracting the gold from the acid, keeps it ſuſpended, along with itſelf, on the ſurface of the aqua regia: while the others, which are found to do the ſame for ſome little time; let it go nevertheleſs at length to the bottom of the veſſel; appearing, by theſe conſequences, at firſt to attract the gold from the aqua regia in the ſame manner as the æther; and keep with it in a ſeparate ſtate; but afterwards to combine gradually with the aqua regia and ſuffer a depart of the gold: the compound, or mixture of the dulcified ſpirits of nitre and ſea ſalts, of which in fact the new formed fluid is conſtituted, being neutral to gold. So that, in the caſe of the æther, the ſeparation is made by the ſuperior attraction of the æther to aqua regia, with reſpect to gold: and in that of the others, by the neutralizing power, which alcohol, or eſſential oils, have on aqua regia, in relation to the ſame object.

This effect of the commixture of æther, alcohol, or eſſential oils, with ſolution of gold in aqua regia, is not yet reduced to any practical uſe.

EXPERIMENT VII.

Solution of gold in vinous ſpirit, by the mediation of nitre, alum, and ſea ſalt; called the ſolution in ſtrepitu.

Take nitre; alum; ſea ſalt; and leaves of gold, ſuch as are uſed for gilding; and grind the whole together to an impalpable powder. Put the powder then into a mattraſs; and, having added water, in the proportion of ſix times the weight of the whole, make it boil ſtrongly; and continue the boiling heat, till the whole be evaporated; and the ſalt remaining at the bottom be of a yellow colour: on the failure of which appearance, freſh water muſt be re-added; and the coction and exhalation repeated, till it be produced. On this yellow ſalt, reduced to dryneſs and powdered, pour eight or ten times its weight of ſpirit of wine: which will inſtantly take the yellow colour from the ſalt, by combining with the gold: which it will hold in a diſſolved ſtate.

OBSERVATION.

This ſolution is termed *ſine ſtrepitu*; becauſe the magiſtery obtained from it, by precipitation through lixiviate ſalts, which has the red or purple colour, and other ſenſible qualities of the aurum fulminans, is, nevertheleſs, devoid of its exploſive property. The proceſs is one of the oldeſt known to be practiſed on gold, and mentioned by Zwelfer: and the ſolution has the quality of gilding iron, as is ſaid, in a beautiful manner; if the iron be only dipt in the ſolution and dried. It is not, however, at preſent uſed in any practical view: nor even mentioned by chemical writers in general: though it is certainly not leſs curious than many others.

EXPERIMENT VIII.

Volatilization of gold, by the fuming compound of ſpirit of ſalt and tin.

Take two ounces of tin, with two ounces and a half of quick ſilver; and amalgamate them: and then commix the amalgama, by grinding them together, with an equal weight of corroſive ſublimate. Put this mixture into a retort: and, having fitted to it a very capacious receiver, with a ſmall hole on its ſide, and thoroughly well ſecured the juncture by lute, diſtil very gradually; and there will come over a fluid ſo extremely volatile, that it will exhale, if expoſed to the air in an unſtopt bottle, with great quickneſs, in white denſe fumes, till the whole be diſſipated.

Add then two parts of this fuming compound to the magiſtery of gold, made by precipitation through the means of tin: and, having put it in a retort, diſtil with a ſlow heat; and, after part of the fuming compound is come over, the gold will follow with the reſt; condenſing againſt the neck of the retort, and the ſides of the receiver, in the form of a reſin, of a bright red colour: which, being collected, will melt and become fluid as oil, on the acceſs of the ſlighteſt heat; but grow hard again, on becoming of the common degree of coldneſs of the atmoſphere.

OBSER-

OBSERVATION.

This proceſs is delivered on the authority of ſome German writers not unworthy of credit: and is, if true, extremely curious. The reſin-like ſubſtance, thus produced, may with great reaſon be ſuſpected to be the ſubſtance uſed in the pretended miracle of the liquefaction of ſaint Gennarius's blood at Naples: having the qualities neceſſary to produce thoſe appearances, by means eaſily concealed. The fuming compound is alſo a very extraordinary ſubſtance; but much more known than the volatilized reſin-like gold: being a ſingular inſtance of any compound, in which a metallic body has a part, that is ſo volatile as to riſe, in an intire ſtate, in a vaporous form, without the leaſt aid of greater heat, than that of the atmoſphere, when moſt cold. It is generally called *the fuming ſpirit of Libavius*; from the ſuppoſition, that he was the inventor, and firſt publiſher of it: but others have put in a claim of the ſame kind.

EXPERIMENT IX.

Demonſtration of the fixity of ſilver.

See Experiment I. on gold: the ſame holding good with reſpect to ſilver.

EXPERIMENT X.

Separation of ſilver from heterogeneous ſubſtances commixt with it in its mineral ſtate, by ſcorification with lead, and ſubſequent cupellation.

See Experiment II. on gold: the ſame means availing with relation to ſilver.

EXPERIMENT XI.

Separation of ſilver from other metallic bodies (except gold and platina) by the combuſtive action of nitre fuſed with it.

See Experiment III. on gold: the ſame being true with relation to ſilver.

EXPERIMENT XII.

Solution of ſilver in ſpirit of nitre.

Take ſpirit of nitre prepared, according to what is laid down in page 330. Vol. I. and, having ſeparated about a thirtieth or fortieth part of what is to be uſed, put it into a ſmall glaſs body; and, having placed it in a gentle heat, add to it as much ſilver as it will diſſolve. When it is ſaturated with ſilver, ſuffer it to grow cold; and then, having filtered the ſolution through paper, drop part of it gradually into the whole quantity of the ſpirit of nitre. A turbidneſs will be produced in it, by the ſeparation of the ſilver: which muſt be ſuffered to ſubſide before another quantity be added: and repeat this, till the ſpirit of nitre continue clear, notwithſtanding more be dropt of the ſolution into it. Let it ſtand then at reſt, for ſome days; and afterwards pour off the clear fluid from the powder, that has been precipitated; and the ſpirit of nitre will be, by this means, duly purified for the ſolution of ſilver.

To the ſpirit of nitre thus purified, and put into a proper glaſs body, add the ſilver, formed into thin plates, in any proportion not exceeding half the weight of the ſpirit of nitre: and place the body in a gentle heat. Where let it remain for a due ſeaſon; and the ſilver will be wholly diſſolved; continuing ſuſpended in it any length of time.

OBSERVATION.

The purification of the nitre, by means of previous ſolution of ſilver, is to free it from any oil of vitriol, or ſpirit of ſalt, which may be combined with it; and would, if not ſeparated, make a precipitation of the ſilver afterwards: as ſpirit of nitre, commixt with either of thoſe acids, becomes a corrodent; and not a diſſolvent of that metal.

This operation is conſtantly practiſed on ſilver, for the ſeparation of gold from it, when the proportion is not greater than one fourth part of the ſilver. The ſilver is, in ſuch caſe, recovered moſt uſually from the ſpirit of nitre, by a precipitation made through the means of thin copper plates, immerſed in the ſolution, till, by the ſuperior attraction that copper has with acids, the ſilver is departed in the form of a grey or blackiſh powder; which is again converted into a reguline ſtate by fuſion, with a flux compoſed of equal parts of calcined borax and nitre. The ſolution of copper, thus produced in the precipitation of the ſilver, is employed, to make the pigment uſed in painting called *verditer*; which is done, by adding chalk purified, by waſhing over as directed in page 169. Vol. I., to the compoſition. This chalk, being in part diſſolved by the ſpirit of nitre, and precipitating the copper from it among the undiſſolved part, produces the verditer; which is in fact only the leſs alkaline part of chalk, commixt with the magiſtery of copper precipitated by the more alkaline part.

The ſolution of ſilver is, likewiſe, made for the production of a preparation uſed in chirurgery called the *lunar cauſtic*; which is the compound of ſilver and ſpirit of nitre, brought to dryneſs by evaporation; and then fuſed by heat, and caſt in molds.—The ſame ſubſtance was formerly prepared in a chryſtalline ſtate; to which the ſalt formed by ſilver and ſpirit of nitre is not reluctant.

This ſolution is, alſo, ſometimes practiſed with a view to the procuring a dye for red or light hair; which being frequently embrocated with it, is changed brown or blackiſh: to facilitate the which, the previouſly moiſtening it with a dilute ſolution of lixiviate ſalt, will greatly contribute. The ſolution, prepared in this intention, is called, by thoſe who ſell it, the *Greek water*.

EXPERIMENT XIII.

Precipitation of ſilver diſſolved in ſpirit of nitre, by the addition of the ſpirit of ſea ſalt.

Take the ſolution of ſilver, as made in the preceding experiment; and drop into it gradually, ſpirit of ſalt,---or a ſolution of common ſalt, or ſal Ammoniacus, in water, ſo long as any turbidneſs or milky whiteneſs, ſhall appear to be produced, on the further addition. Let it then ſtand at reſt; and, adding water copiouſly to the fluid, the ſilver will be precipitated, in the form of a white powder, though not departed from the acid, which before held it diſſolved, as in moſt other inſtances of precipitation; but combined with ſome proportion of that, and with the other acid ſuperadded.

If this precipitated matter be ſeparated from the ſupernatant fluid by decantation, ablution with freſh water, and deſication; and then fuſed with a moderate heat; it will form a ſemi-pellucid reddiſh maſs, with ſome degree of flexibility: which, from reſemblance of horn, is called the *luna cornea*.

OBSERVATION.

This operation is performed on the principle of a *corroſion by depart*, as explained in p. 21. Vol. I: for the ſilver is not departed from the ſpirit of nitre, by the ſuperior attraction of the ſpirit of ſalt, which is, indeed, of a lower order in the ſeries of the alkaline genus, according to the manner in which moſt other precipitations are made; but, in conſequence of a combination with both the acids, which, when conjoined with it, form a compound reluctant to ſolution in water: as, if they were previouſly commixt, before they were made to act on the ſilver, they would prove a corroding, and not a diſſolving menſtruum to it. The addition of ſolution of common ſalt, or ſal Ammoniacus, anſwers the ſame end as ſpirit of ſalt; becauſe the acid, contained in either of thoſe ſalts, is departed by the ſuperior attraction of the ſpirit of nitre on their alkaline baſis; and, conſequently, becomes preſent in the compound fluid, in a manner equivalent to that of its being added ſimply.

The precipitation of ſilver from the ſpirit of nitre, by the addition of ſpirit of ſea ſalt, is ſometimes practiſed on the ſolutions made in the view of ſeparating other metals combined with it from the ſilver; and, in this caſe, the luna cornea, or precipitated compound of the ſilver and acid, may be made to yield the ſilver in its proper form, by fuſion with a flux compoſed of calcined borax and nitre.

The luna cornea from its having a vitreous appearance, with ſome flexibility, has been thought by many to be the malleable glaſs of the ancients; and may be made, by caſting it in proper molds, into the form of drinking glaſſes, or other veſſels; which will have a great reſemblance with thoſe formed of glaſs.

EXPERIMENT XIV.

Chryſtallization of the nitrous ſalt of ſilver in the reſemblance of ſome vegetables: commonly called Diana's tree.

Diſſolve an ounce of ſilver in three ounces of ſpirit of nitre, as above directed: and, adding to it eighteen ounces of water, and two ounces of mercury, put the mixture into a mattraſs of tranſparent colourleſs glaſs, that will juſt contain the whole. Fix the mattraſs in a frame of wood that will keep it ſteady, and yet ſuffer the bulb to be ſeen through diſtinctly: and, ſtopping up the orifice of the neck ſecurely, place it then in a quiet ſituation, where it may not be ſubject to be ſhaken; and let it ſtand at reſt for five or ſix weeks. During that time, the appearance of a tree with a great number of ramifications, or branches, will ariſe from the mercury: which has occaſioned this ſaline production to be called *Diana's tree.*

OBSER-

OBSERVATION.

This proceſs is not practiſed for any uſeful purpoſe; but the reſemblance of the chryſtals to the form of ſome vegetables, rendered it entertaining as an amuſement: and gave occaſion to the earlier chemiſts, to ſuppoſe relations of a myſterious kind to ſubſiſt betwixt vegetables and metallic bodies.

EXPERIMENT XV.

Converſion of copper into braſs, by cementation with lapis calaminaris.

Take lapis calaminaris, prepared by uſtulation, if it abound in ſulphur or arſenic; and mix with it an equal weight of charcoal, by grinding them well together. Put this matter into a proper melting pot: and, over it, lay thin plates of copper, cut into narrow pieces, in the proportion of two thirds of the weight of the mixture of the lapis calaminaris, and coal; and cover it over, alſo, with powdered charcoal. Place the melting pot, thus charged, in any proper furnace, where it may undergo a due degree of heat; and, ſurrounding it with coals, raiſe the fire, therefore, gradually till the pot be heated of a luminous whiteneſs. Continue things in this ſtate, till the matter emits a flame of a bluiſh or a purple colour: and examine then, by means of a ſtrong iron wire, if the copper be melted: which will be effected by leſs heat than would fuſe it alone. If it be yet found in a ſolid form, the ſame degree of heat muſt be ſometime longer continued; and if, on a ſecond trial, it ſtill continue in the ſame ſtate, the fire muſt be a little increaſed: and a third examination made. When the copper appears to be thoroughly liquefied, the pot muſt be taken out of the fire; and ſuffered to cool of itſelf: or, if the quantity of copper employed were larger, the melted maſs may be poured into a proper mold moderately heated; and when cold, it will no longer be found to be copper; but changed into braſs: a compound metal of a colour more yellow; and more nearly reſembling gold. The quantity of the metal will be alſo increaſed, if the operation ſucceed: which will be, in ſome proportion,

tion, from one fourth to one third of the weight of the copper ſubjected to the operation.

OBSERVATION.

The change thus produced in the metal, both with reſpect to the colour, and the augmentation of the quantity, is owing principally to its imbibing a proportion of zinc, nearly equal to ſuch increaſe of the quantity: which, being ſublimed by the heat out of the lapis calaminaris, is combined, in that ſtate, with the copper prepared to abſorb it, by the ſame heat: in order to which, the copper is formed into plates, that there may be the greater quantity of attracting ſurface in contact with the fumes. The charcoal powder is added, to counteract the calcining power of the heat, as well on the zinc in the lapis calaminaris, as on the copper itſelf; in order to the better defending both which from this effect, that would be rendered ſtronger by the acceſs of the air, the powdered charcoal is put over them. It is not, however, by the ſimple combination of the zinc and copper, that braſs is produced: for, if the ſame proportions of theſe two metallic bodies be fuſed together, though they appear to be perfectly united, yet a compound, greatly varying from braſs in ſeveral of its qualities, is formed; particularly in its malleability; and in having a ſtronger yellow colour verging towards green;

which, nevertheleſs, ſoon changes to a green dulneſs with the acceſs of the air. This compound of copper and zinc, made by combination through colliquation by fuſing them together in the proportion of ſix or four parts of copper to one of zinc, is called *Prince Rupert's metal*, or more commonly, at preſent, *Princes metal*, or *Bath metal*; and by the French *Tombac*: and it was formerly much in uſe: but the want of malleability, and the growing green and dull, in a ſhort time, when expoſed to the air, have occaſioned its giving place to the other compoſitions, that, with equal beauty, are freer from theſe defects.

EXPERIMENT XVI.

Calcination, and vitrification per ſe, of lead.

Take lead: and, having put it in a teſt, or other veſſel, where it may have a broad ſurface, heat it luminouſly hot: and it will boil, and gradually be converted into a grey calx. Spread this calx on a tile, and put it again into the fire, which ſhould not be too ſtrong, and the colour will be changed, firſt to a yellowiſh brown; and, afterwards, to an orange red: in which ſtate it is called *minium*, or red lead. Put the minium into a melting pot, ſuch as thoſe of which the manner of fabrication is given p. 161. Vol. I. and, bringing it again to a luminous degree of heat, it will vitrify; forming a yellow glaſs.

OBSERVATION.

The calcination of lead for the production of red lead is practiſed in very large works; where furnaces like ovens are made for the diſpatch of large quantities: and it is, alſo, performed in the ſcorification of metals. The vitrification of lead per ſe, is not, however, done intentionally on any commercial account, unleſs with a view to the making compoſitions for painting in enamel, or on glaſs, the glaſs produced, not having ſuch properties as render it uſeful: but it is ſubſerviently performed in the view of the purification of other metals; and of the ſeparation of them from each other.

EXPERIMENT XVII.

Change of the natural texture, and hue of tin, into a plumoſe form, and high yellow colour (reſembling that of gold), by commixture with mercury, mineral ſulphur, and ſal Ammoniacus; and a re-ſeparation by ſublimation of the three added ſubſtances.

Take of tin, one pound: of flowers of ſulphur, ſeven ounces; and of pure mercury,

cury, and ſal Ammoniacus, each half a pound. Add the quickſilver to the tin, previouſly melted, but not heated more than is requiſite to liquefaction; ſtirring them about till they be thoroughly combined: and, when the maſs is cold, powder, and mix it intimately with the ſal Ammoniacus and flowers of ſulphur by grinding them together. Put the mixture into a coated body of long form; and fix it in the cavity of a proper furnace, where only about one third may be expoſed to the naked fire. Cover the mouth of the body with a piece of tile; and then ſublime with a gradual heat, ſo long as any part of the matter riſes: which may be diſtinguiſhed by the continuance, or abatement of the heat of the body, under the ſame force of fire. When the ſublimation is over, let the fire extinguiſh: and, when the body is cold, take it out of the furnace, as gently as poſſible: and, if it be whole, divide it in the middle, by means of an iron ring, according to the directions p. 89. Vol. I. or, in default of ſuch ring, by turning it againſt a poker heated red hot: by which means, the ſublimed matter in the upper part may be prevented from falling on the maſs of tin in the lower; which will be found in a light cake of matter of a ſoft plumoſe texture, and a bright yellow colour, reſembling gold: on which account it has been called *aurum Moſaicum*, or *Muſivum*.

OBSERVATION.

The effect, which the ſulphur has on tin, by this treatment, is very curious: and conduces to demonſtrate, that the colour in bodies depend on phlogiſton. The uſe of the mercury, in the proceſs, is to bring the tin to a ſtate, in which it may be miſcible with the ſulphur; and to prevent, by its ſuperior attraction, the ſulphur's combining with the tin, and being fixt by it; and that of the ſal Ammoniacus is, to render the ſublimation of the ſulphur more perfect. The coloured tin, or aurum Moſaicum, on being kept for ſome time in a luminous degree of heat, in an open veſſel ſtirred about; and, afterwards, fluxt in an open veſſel, with the addition of a little tallow and charcoal duſt, will be reduced to its metallic ſtate.

This proceſs is practiſed as well for preparing the aurum Moſaicum for medicinal uſes; as for the purpoſe of bronzing or colouring (in imitation of gilding) plaſter figures, &c. to which application, its ſoft fat texture extremely well fits it; as it will cohere to ſuch bodies without any cement, or glutinous medium. A ſubſtance correſpondent to this, but of a white colour, and called on that account by ſome of the German artificers and chemiſts, *argentum Muſivum*, is prepared, by amalgamating equal parts of tin, biſmuth, and mercury together: the tin and biſmuth being firſt commixt by fuſing them together; and the mercury, afterwnrds, added to them, while yet hot: which compound when cold, being of the ſame texture with the aurum Moſaicum, will anſwer the like end with reſpect to colouring plaſter figures, &c. excepting the difference of colour.

EXPERIMENT XVIII.

Volatilization of tin, by combination with ſpirit of ſalt.

See Experiment VIII.

EXPERIMENT XIX.

Converſion of the crude regulus of iron, called pig, *or* caſt iron, *into malleable, or forged, iron, by fuſion in fires of vegetable coal, and percuſſion with large hammers.*

Prepare a proper hollow bed on a ſmith's, or any other ſuch, hearth; and, having coated its ſurface with charcoal duſt, and lute, let it be well dried. Take then the crude iron; and lay it over coals on the bed, ſurrounding it, likewiſe, with others heaped upon it; and, having kindled them, raiſe the fire by the blaſt of the bellows, that the iron may be brought to fuſion: to which, if it be reluctant, it muſt be urged by the addition of fluxes or vitreſcent ſand. The fire need not, however, be made ſtronger than is required to the thorough liquefaction of all the matter: which, being effected, the melted maſs muſt be ſtirred well about, that the whole may ſucceſſively be expoſed to the action of the air and fire. The ſcoriæ muſt be, likewiſe, ſeveral times taken off, as they appear to be formed in a ſufficient quantity; the iron, in the mean time, emitting a multitude of ſparks, like a ſhower of fire, by the diminution of which, it muſt be determined, how near it is to its requiſite degree of purity. When that appears, let the coals be removed; and the remaining ſcoria drawn off by a channel made from the hollow bed through the hearth for that purpoſe; and the iron, when it reaſſumes its ſolid form, but is yet white hot, and ſufficiently ſoft to be drawn out in long pieces, muſt ſuffer the ſtrokes of a heavy hammer; by which, if it readily undergo extenſion in every direction, it is a proof, that the fuſion has had a due effect. But it muſt be, afterwards, wrought to the purity required, by alternately heating it white hot, in the fire; and beating it with the hammer, till it grow too cold to bear extenſion freely.

OBSERVATION.

In this proceſs, a change is wrought on the iron, by bringing it from the crude condition in which it is obtained from the ore, mixt with other foſſile ſubſtances, particularly by mineral ſulphur, to a more pure and perfect ſtate, on the following principles.

The iron, whether in its metallic, or calceous form, in the ſtate of ore, is almoſt conſtantly mixt with a large proportion of heterogeneous matter: which, beſides the mineral ſulphur, are as well arſenic, and other metallic bodies, as lapidaceous earths. Theſe ſubſtances, though in part ſeparated by the uſtulation, and eliquation, which the matter undergoes in the operation by which the crude iron is recovered from the ore, are yet by no means wholly extracted from it: as all metallic bodies, except lead, readily combine with it, by colliquation; and the great degree of heat neceſſary to the fuſion, and eliquation of the iron from the ore, brings the more refractory of the vitreſcent lapidaceous earths to ſuch a viſcid ſtate, that they are extremely apt to adhere to, and remain commixt with, the reguline maſs. But the great difference betwixt the crude and malleable iron, conſiſts, nevertheleſs, in that the crude is compounded, in part of mineral ſulphur; which ſupplies the place of phlogiſton in a purer form, in its metallic conſtitution: and the phlogiſton, in ſuch mineral ſulphur, being controlled in its property of giving malleability to metals, as it is, indeed, in moſt of its others, by combination with the vitriolic acid, is not capable, therefore, of rendering the iron perfect. The mineral ſulphur, conſequently, requires to be expelled from the iron; and to have its place ſupplied with another kind of ſulphur, ſuch as that exiſting in the coal of animal or vegetable ſubſtances; in which the phlogiſton is not rendered incapable of reſtoring their metalleity in a more perfect degree, to the calces of metallic bodies, when combined with them. A ſecond fuſion, therefore, in the coal of vegetables, conduces to theſe ſeveral intentions, by expoſing the mineral ſulphur, both to exhale by the heat, and to be decompounded by the combuſtive action of the air on it in that ſtate;

while,

while, at the ſame time, its place is ſupplied by the purer ſulphur of the charcoal in contact with it: and the more perfect liquefaction of the whole maſs cauſes the true reguline part of the iron to be precipitated from the ſcoria; which, by their leſs ſpecific gravity, floating on the ſurface, may be eaſily ſeparated; eſpecially when the iron, now grown more reluctant, by this purification from the fluxing bodies to fuſion, reaſſumes a ſolid ſtate in that degree of heat, which keeps the ſcoria in perfect liquefaction. The percuſſion by the hammer, and the repeated alternate calefactions, ſtill further contribute to this melioration of the iron: as well by a further change of the mineral ſulphur for that purer kind afforded by the vegetable coal; as by ſeparating all the ſcoria and heterogeneous parts: which are made to fly off from the ſurface, by the ſtrokes of the hammer, as the iron grows colder, and aſſumes a more rigid texture.

This proceſs, with variations according to the different nature of the crude iron, and that of the malleable intended to be produced; and in ſome caſes, alſo, according to the different cuſtoms or notions of the conducters of the works; is practiſed in large in the forges appropriated to this end. But the re-fuſion of the iron is generally omitted in the countries where wood is ſcarce; as it requires too great a conſumption of coal; and the pigs are only formed into blooms, as they are called, by ſoftening them with heat; and, afterwards, into bars, by a more continued calefaction in ſuch a degree of fire, as will only render the iron extenſible, attended with repeated percuſſions.

EXPERIMENT XX.

Converſion of malleable or forged iron into ſteel, by cementation with the coal of animal or vegetable ſubſtances.

Take the beſt kind of forged iron; and forge it into ſmall bars of a flat form. Prepare then long coffins of the matter directed for making teſts, page III, Vol. I. or of any other compoſition of earth or clay, that will endure the fire, without flying or cracking in a long continued heat; and, having baked them in the fire to a firm conſiſtence, cover the bottom of them with the cementing compoſition thus prepared. Powder groſly ſound, well burnt, charcoal; and mix it with the coal of leather, bones, blood, or other animal ſubſtance powdered, and the aſhes of wood retaining the lixiviate ſalt, in the proportion of two parts of the vegetable coal, one part of the animal coal, and a half part of the wood aſhes. On this matter, ſpread on the bottom of the coffin, lay a ſtratum of the bars of the iron; and, over them, put another ſtratum of the cement: and proceed, in this manner, to fill the coffin; letting, nevertheleſs, the uppermoſt, as well as the undermoſt, ſtratum, be of the cement.---Or in the place of the coffins, or long veſſels, pots, of a cylindrical form, may be uſed: in which caſe, a thicker ſtratum of cement being put at the bottom, the bars, inſtead of being laid horizontally, muſt be ſet up perpendicularly, at about an inch diſtance from each other; and the ſpace betwixt them filled up by cement forced in by ſtrong preſſure: a ſtratum of the ſame being, likewiſe, put over them; in order to which it is proper, that the bars ſhould be formed ſo much leſs than the pot, as to allow for the cement lying under and over them. Which ever of theſe kinds of veſſels are employed, they muſt be, after they are thus charged with the iron and cement, covered with a proper lid; and the juncture well cloſed with lute that will endure the fire, but made without colcothar, or calcined vitriol. The coffins, or pots, muſt then be put into a furnace; and, being ſurrounded with coals, a fire muſt be raiſed, that will bring them to luminous whiteneſs: in which ſtate, they muſt be continued for ſix or eight hours. When, the coffin or pot being taken out, the bars, while they are yet hot, muſt be immerſed in cold water: and, when cold, they will be found to be converted into ſteel: having acquired theſe qualities; the want of malleability, attended with ſuch a hardneſs as to reſiſt the file; which may be again nevertheleſs reſtored, by the ſteel's being heated to a luminous degree, and cooled gradually:— the being of greater tenacity; — and the having a ſmaller grain; and a darker colour, reſembling in ſome degree the appearance of water.

OBSERVATION.

The principle of this converſion of malleable iron to ſteel, by cementation, is ſolely, the exchange of the mineral ſulphur remaining in the iron, for a purer kind attracted from the coal in the cement. The converſion of iron to ſteel has been, nevertheleſs, imputed hitherto to the proportion, rather than the nature, of the ſulphur combined with the metallic earth: and, if ſteel were to be produced by cementation

tion in cloſe veſſels only, it might be a plauſible account of the matter. But, as the ſame effect may be cauſed by fuſion, and calefaction, according to the proceſs next following, in a manner, that rather tends to diminiſh than augment the quantity of phlogiſton in the iron, it is warranted, by a juſt induction from the facts, to aſcribe it to the other cauſe: and, moreover, the depravation of iron, by the fumes of mineral ſulphur, or the vitriolic acid, which again bring it back to the ſtate of crude immalleable iron; with the reconverſion it is again capable of to common forged iron, or ſteel, by calefaction with the contact of animal and vegetable coal, and the excluſion of the fumes of mineral ſulphur or the vitriolic acid; afford an experimentum crucis, with reſpect to this point.

This proceſs is commonly practiſed in large in our own country, for the converſion of iron to ſteel; but with ſome variations from the manner here delivered. For the bars being larger, a much longer time is allowed for the production of the due effect: and the furnace is heated with mineral coal; though it is affirmed even by ſome of the lateſt German writers, that this is not practicable. There is, however, no reaſon againſt it, either in theory or practice, provided the acceſs of the fumes of the pit coal, which always contain a large proportion of mineral ſulphur, be wholly prevented by the impervious texture of the veſſels uſed to contain the iron and cement; and by the cloſeneſs of the juncture, from the compactneſs of the lute.

Allowing this principle, that the change from crude or pig iron, ſuch as is obtained by eliquation from the ore, to malleable or forged iron, lies chiefly in the expelling the mineral ſulphur from the metal, and re-impregnating it with phlogiſton in a purer ſtate, the reaſon may be clearly reduced, why iron is produced of ſuch different qualities in different places; and why, we are obliged to have recourſe to the northern parts of Europe or America for ſuch as we want of a more perfect kind, notwithſtanding our own country abounds with iron ores, as good perhaps as any, from which that metal has ever been hitherto extracted in large. For, according to the methods at preſent in uſe, it being required, where great quantities are in queſtion, that either the excoction, or calefaction in a ſolid ſtate, neceſſary to expel the mineral ſulphur, ſhould be performed in open fires, the coal of vegetables only can be uſed: which makes ſo great a conſumption of wood that it enhances the expence beyond what is equivalent to the rate, at which equally good can be imported from abroad. This renders it an object extremely well worthy conſideration, how to produce the ſame effect without being obliged to perform the whole of the proceſs in open fires of charcoal, inſtead of employing pit coal; in the abundance of which, we have the advantage over moſt other countries. This can be done only by performing the excoction of the mineral ſulphur in cloſe veſſels, and the bar to the accompliſhment of it, therefore, at preſent lies, in the want of melting pots, that being of ſufficient ſize to diſpatch the requiſite quantity, would have the due tenacity to bear the weight of the metal, and at the ſame time reſiſt the vitrifying power of the heat: but I have great reaſon to believe, though the public are not hitherto appriſed of it, that this impediment may be wholly ſurmounted; and that a ſubſtance is diſcovered, and may be obtained on eaſy terms, of which melting pots of any ſize whatever may be formed, with all the qualities neceſſary to the fitting them for this uſe in the moſt perfect manner.

EXPERIMENT XXI.

Converſion of crude iron into ſteel, by refuſion and percuſſion.

Take the beſt ſort of crude iron, that is, ſuch as is neareſt to a malleable ſtate; and fuſe it on a proper hearth, as is directed above in Experiment XIX; only adding ſome ſcoria of a fluxing quality, or ſome vitreſcent ſand or ſtones; and heaping up the coals copiouſly over it. But the blaſt of the bellows ſhould be directed ſo as not to point on the ſurface of the metal, but yet to drive the flame thither in the fulleſt manner poſſible: and the fire ſhould be urged to the degree neceſſary to keep the metal perfectly liquefied. The ſcoriæ, as they are produced in due quantity, ſhould alſo be taken off; and the fluid maſs of metal well ſtirred about. When the ſcoriæ ceaſe to be any longer increaſed in a conſiderable quantity, the coals being removed, they ſhould be intirely drawn off by a channel made for that purpoſe, through the ſide of the hollow bed and the hearth; and the ſolid metal muſt then be cut with a chizzel and hammer, into a proper number of pieces. Being then again heated for ſome time in the ſame kind of fire, but abated in the degree, they muſt be drawn out into ſmall bars, by ſeveral different percuſſions with a heavy hammer, the calefaction being repeated betwixt each, till it be found, on trial, that being immerſed, while luminouſly hot, in cold water, they grow ſo hard as to fly with the ſtroke of a hammer; and wholly reſiſt the action of a file. But the different diſpoſition to this change in different parcels of iron, renders it impracticable to ſettle the number of calefactions, and percuſſions, neceſſary to produce it, by any general rules.

OBSERVATION.

This is the proceſs moſt generally practiſed in Germany, and the northern parts of Europe, for the production of ſteel: but, in our own country, where the ſcarcity of wood occaſions charcoal to be dear, which is only a kind of fewel that can be uſed for this purpoſe where the metal is expoſed to the naked fire, cementation is moſt generally ſubſtituted in the place of it: as that may be performed with pit coal.

Steel, much the ſame in its qualities, may be, however, produced by either method: which evinces, that the difference of iron and ſteel does not conſiſt in the quantity, but the condition of the phlogiſton, that conſtitutes in part the metal. For as in this experiment, the operation rather tends by the force of the heat, with acceſs of the air, to diminiſh than augment the proportion of phlogiſton, (though in the cementation, according to the preceding experiment there is the contrary appearance); it is an irrefragable proof, that the change wrought in the converſion is rather owing to the expelling the mineral ſulphur, and impregnating the metallic earth with phlogiſton, in a more apt ſtate to give the due qualities to the metal, than to an augmentation of its quantity, which (as was before mentioned) is the cauſe, erroneouſly, aſſigned for the converſion of iron into ſteel.

EXPERIMENT XXII.

Volatile calcination of zinc.

Take zinc; and, having put it into a broad melting pot, under a proper chimney, or other fabric, that the fumes may be retained and collected, give it ſuch degree of heat, ſuffering the air to have acceſs, as will cauſe a blue flame to ariſe on the ſurface, attended with white fumes: which being collected in the chimney, or other proper apparatus for that purpoſe, will be found to be a perfect calx; and, contrarily to the nature of thoſe of other metallic bodies, not reducible by the addition of bodies containing phlogiſton, or by any other means hitherto known.—Or take zinc; and, having broken it into ſmall parts, mix it with an equal weight of nitre: and, having heated an earthen retort, to a luminous degree of heat, and fitted to it a large receiver, perforated with a ſmall hole in the ſide, throw in a ſpoonful of the mixture of the zinc and nitre, through a hole of about half an inch diameter,

meter, made, for that end, in the part of the bend of the retort over the center of the bottom; and cover the hole with a light piece of tile or glaſs. A deflagration will enſue: on the ceſſation of which, a ſecond quantity of the zinc and nitre muſt be thrown in as before; and the ſame muſt be repeated till the whole be ſo treated. The zinc being thus calcined by the detonation, the flowers will be found in the receiver.

OBSERVATION.

The volatilization of arſenic, and biſmuth, in the form of a calx, is likewiſe practicable, by the ſame means, in the open air; and that of biſmuth, by nitre alſo in cloſe veſſels. But the acceſs of air is wanting to the calcination of arſenic, even with nitre; as was before obſerved in the experiments and obſervations relating to it in a ſaline view. The calces of theſe two metals are not, however, like zinc, renitent to reduction; but admit of being brought back to their metallic form.

This operation is not practiſed intentionally for any other than experimental purpoſes in the caſe of zinc; but it unavoidably occurs, in the ſeparation of zinc from the ores whence it is obtained, in a manner, that occaſions the loſs of a very great part of what is contained in the ſuch ores, which flies off in fumes; and being collected in the chimnies of the furnaces where this work is done, the concreted maſſes of it are called the *cadmia fornacum*; and are applied, according to the older modes of practice, to ſome purpoſes in medicine. But the calx of biſmuth is ſometimes prepared with nitre in the form of flowers, in the intention of a coſmetic; and arſenic alſo conſtantly by ſimple calcination, in the form of the chryſtalline cakes found in the ſhops: though the principal intention in the ſublimation of the arſenic from the cobalt, from whence it is thus extracted, is the recovery of the *zaffer* or caput mortuum, from it: which is uſed for the preparing ſmalt; and colouring other vitreous bodies.

EXPERIMENT XXIII.

Solution of biſmuth in ſpirit of nitre, and precipitation by means of ſpirit of ſalt.

Proceed as in Experiments XII and XIII, in the caſe of ſilver; or inſtead of the ſpirit or ſolution of ſea ſalt, uſe a ſolution of lixiviate ſalt.

OBSERVATION.

This proceſs, according to the firſt method, is performed in the ſame manner, and on the ſame principle, as that for obtaining the luna cornea from the ſolution of ſilver; being, in fact, a per-precipitation by corroſion, as explained page 21. Vol. I. It is ſometimes practiſed for the preparation of a magiſtery to be uſed as a coſmetic; but the ſalts combined with the metallic ſubſtance render ſuch magiſtery very unfit for that purpoſe: wherefore, it is more proper to uſe the ſublimed flowers, or the magiſtery obtained by the other method of precipitation.

EXPERIMENT XXIV.

Calcination of crude antimony; and the ſubſequent vitrification of it per ſe.

Take crude antimony, obtained from the ore by eliquation, after it has undergone ſuch an uſtulation as frees it from a great part of the mineral ſulphur; and, having powdered it, lay it on a tile, or other ſuch flat body; and, having placed it in a furnace, let it calcine gradually with as ſtrong a heat as it can bear, without fuſion; but ſtir it frequently. In this calcination, the fire may be, however, increaſed, towards the end of the operation, to a greater degree than would fuſe it at firſt. When no further change can be made by heat, applied in this manner, take the calx; and put it in a melting pot proper for vitrification: and, covering the pot, give it a degree of heat ſufficient to bring it to fuſion. After it has continued in this ſtate ſome little time, examine, by dipping into it the ſmall end of a tobacco-pipe, if it be perfectly clear and tranſparent; which being found, take the pot out of the fire; and let it grow cold: then break the pot; and ſeparate it from the matter: which will appear to be an orange-coloured glaſs.

OBSERVATION.

This operation is practiſed for medicinal purpoſes at Venice, or other places abroad: but not in this country, except for experiment. It is a peculiar quality of this glaſs to commenſtruate with wax, on being added in powder to the wax previouſly melted; and continued for ſome time in the ſame degree of heat: as is ſometimes practiſed for medicinal purpoſes.

EXPERIMENT XXV.

Calcination of antimony by detonation with various proportions of nitre.

Take of antimony, four parts; of crude tartar, three parts; and of nitre, two parts. Powder them ſeparately; and, having mixed them together, let them be gradually thrown into a crucible heated red hot; and proceed, as in other caſes of detonation, till the whole be ſo treated. Fuſe the matter then with a degree of heat that will render the matter luminouſly hot: and then pour it into a proper conic mold well greaſed. When it is cold, it will be found that the reguline part of the antimony, being freed from the mineral ſulphur, with which it was combined in the crude antimony, will be collected in the mold, in a metalline form: part of the ſulphur commixt with the ſalts forming a ſcoria over it.

Or take of antimony, eight ounces; and of nitre, ſix; and, being ſeparately powdered, let them be well mixed together; and treated as the preceding mixture. The ſcoria being removed, inſtead of a reguline body, there will be found a yellowiſh liver-coloured ſubſtance, reſembling a mixture of red glaſs and metal; which is called the *crocus metallorum*: and, by the college of phyſicians of London, *crocus antimonii*. If a greater proportion of nitre; but not exceeding twice the quantity of the antimony, be added,—or if the matter be kept for a longer time in fuſion,—the colour will grow, conſequently, more yellow.

Or let the proportion of the nitre be three times the weight of the antimony; and the ſubſequent treatment, as with the others: and a white perfect calx will be produced; which may be freed from the ſalts by ablution.

OBSERVATION.

It is practiſed to calcine antimony, according to the firſt of theſe proportions, for obtaining the regulus of antimony, for medicinal uſes, and for procuring the precipitated ſulphur from the ſcoria: which is done by diſſolving the ſcoria in boiling water; and making a depart of the ſulphur from the lixiviate ſalt, generated by the combuſtion from the tartar and nitre, by the addition of any acid. The ſulphur, ſo prepared, is called, from its yellow colour, the *ſulphur auratum antimonii*: and is of the ſame nature with the *kermes minerale*; of which the preparation differs only in combining the lixiviate ſalt with the ſulphur, by coction in water: and this ſulphur, prepared by one of theſe methods, is the medicine by which an eminent empyric raiſed his reputation through its efficacy in ſome extraordinary caſes: but the great uncertainty of the action of antimonial preparations in different conſtitutions, ſometimes producing little or no effect, and at other times operating with malignant, and even fatal violence, has baniſhed the uſe of this, and moſt others, from regular practice. The regulus of antimony is, however, more frequently prepared, as well for medicinal, as metallurgic purpoſes, by a precipitation of the regulus from the crude antimony, through the means of iron, in the following manner. Put a pound of iron nails into a large crucible; and, having heated them luminouſly white, add to them crude antimony, half a pound, mixt with two ounces of nitre, and one of tartar, or, with half a pound of ſal polychreſt; and proceed as in the above given method.

Antimony is calcined, according to the ſecond of theſe proportions, alſo, for the preparation of the crocus metallorum, or antimonii, for medicinal purpoſes: of which, nevertheleſs, the principal uſe, at preſent, is the exhibition of it to horſes by farriers. But, when great quantities are in queſtion, the trouble and expence of exterior fire is ſaved, by producing the due effect through the heat generated in the detonation of the ſulphur of the antimony, and the nitre: which is thus managed. Put the antimony, and nitre, with about a thirtieth part of the whole of ſea ſalt, powdered together into an iron pot, ſuch as is commonly uſed for boiling fleſh; and cover the pot with a flat piece of iron, or ſtone, that may cloſe it, ſo that there may be only a ſmall vent for the fumes. Set the pot in an open place in the air: and fire the mixture contained in it by means of an iron rod, or tobacco-pipe, heated red hot, and thruſt into it: in conſequence of which, a deflagration will be excited; and will continue ſpontaneouſly, till the calcination be duly effected, as in the caſe of exterior fire. But this can only be practiſed, where a large quantity of the matter is to be ſubjected to the operation.

The calcination of antimony, according to the third of theſe proportions,—or, what is the ſame with reſpect to the effect, with any quantity of nitre ſufficient to cauſe the deflagration of the whole of the ſulphur, or phlogiſton contained in it,—is performed likewiſe for medicinal purpoſes. The calx, ſo obtained, paſſing, according to variations in the manner of the operation, which, however, make no difference in the produce, under the names of *diaphoretic antimony*, and *bezoar mineral*; and, with the addition of ſome proportion of imperfectly calcined red precipitate, making, alſo, the *fever powder* now in ſo great reputation with the public.

EXPERIMENT XXVI.

Volatilization of antimony, by combination with ſpirit of ſalt.

Take of antimony, one pound; and corroſive ſublimate, two pounds; and, having powdered them ſeparately, let them be thoroughly well mixt, by grinding them together in a glaſs or marble mortar. Put the mixture then into a retort, of which the neck ſhould be large: and, placing it in a ſand bath, raiſe a ſtrong fire. The reguline part of the antimony re-ſeparating from the mineral ſulphur with which it was before combined in the crude antimony, and the ſpirit of ſalt, quitting, alſo, the mercury with which it was combined in the corroſive ſublimate, will commenſtruate; and riſe into the neck of the retort, and the receiver, in an unctuous maſs, called, from its conſiſtence, the *butter of antimony*; leaving the mercury and mineral ſulphur combined together in the bottom of the retort: though with a ſtronger degree of heat, they will riſe, likewiſe, in the form of cinnabar: which, when thus prepared, is called *cinnabar of antimony.*

OBSERVATION.

In this proceſs, a double depart is made: for the ſpirit of ſalt, quitting the mercury in conſequence of its ſuperior attraction with the reguline part of the antimony, and combining with ſuch reguline part, departs the mineral ſulphur from it: which, being thus ſet at liberty, and regaining, as it were, a ſimple ſtate, commenſtruates, through the mediation of the due degree of heat for their combination, with the mercury, brought, alſo, to the ſame ſtate by its ſeparation from the ſpirit of ſalt. The power of the ſpirit of ſalt, as diſplayed in this experiment of volatilizing a metallic body, is not confined to antimony; but extends to tin, mercury, and, perhaps, even gold, as appears in the experiments exhibited relating to thoſe bodies.

The proceſs is practiſed for medicinal uſes; as well for the obtaining the butter of antimony, which is uſed as a cauſtic (though of late but ſeldom); as the cinnabar of antimony, which has, at preſent, the reputation of an efficacious medicine, though on very dubious grounds.

EXPERIMENT XXVII.

Calcination of arſenic.

See Experiment XXII; and obſervation on it.

EXPERIMENT XXVIII.

Demonſtration of the fixity of platina in every degree of heat producible on the principle of culinary fire; and its reſiſtance of the combuſtive action of nitre.

Proceed as in the caſe of gold, Experiment I: and the conſequence will be the ſame.

EXPERIMENT XXIX.

Demonſtration of the invitrifiability of platina, even by the force of vitrifactive fluxes.

Take of common white glaſs powdered, twelve drams; of the magiſtery of platina, one dram. Mix them well together; and, having put them in a proper pot for vitrification, (ſuch as is deſcribed page 161. Vol. I.) give the proper degree of heat to make the glaſs boil; and keep it in this ſtate for eight or ten hours. The glaſs will be found to be no otherwiſe changed than by being rendered leſs tranſparent; in ſuch manner, as long calefaction when in a ſmall maſs, or the addition of a minute quantity of phlogiſton will occaſion: and the platina will be commixt in ſmall grains diſperſed on the glaſs in a metallic form; and contributing to its opacity.

OBSERVATION.

It may be preſumed from this experiment, that if the magiſtery of platina were to be ſubjected to a ſtrong heat, commixt with glaſs, of which the vitrifactive property on other bodies was increaſed by any proportion of calcined lead, borax, or arſenic, ſubſtances with the higheſt fluxing property, it would ſtill remain unvitrified: but I am not authoriſed from any thing hitherto related of the examination of the nature of platina, to affirm more poſitively than this experiment infers. For Dr. Lewis, who is the only perſon, as far as I know, that has made any trials of the diſpoſition of this ſubſtance, with regard to its vitreſcence, does not appear, in the caſe of the magiſtery, to have employed any other flux, than different proportions of what he calls *common white glaſs*: by which, I ſuppoſe, is meant the kind moſt generally in uſe, under the name of *flint-*

glaſs: though it were to be wiſhed, he had demonſtrated the abſolute invitrifiability of platina, by bringing the magiſtery of it, as well as the intire body, to the teſt of more active fluxes. As the ſtrength and continuance of the heat applied is, however, ſubſtitutively equivalent to the force of fluxes in the vitrifactive œconomy, there is the juſteſt grounds to conclude, from the reſiſtance of the platina to an intenſe heat for ten hours, as in this experiment, without the leaſt mark of its ſuffering any change, that it would not yield even to the ſtrongeſt action of fluxes, but be found abſolutely invitrifiable.

EXPERIMENT XXX.

Solution of platina in aqua regia; and chryſtallization of the ſalt produced.

Take four ounces of platina powdered, and ſeven ounces of aqua regia, prepared by any of the methods directed Experiment IV; and, having put them into a proper phial, or ſmall mattraſs, place it in a ſand bath: where the platina will be diſſolved. Filter the ſolution; and, evaporating it to the due proportion, ſet it in a cold place to ſhoot; and chryſtals will be formed of a dark opake red colour, and of a foliated form, like the flowers of Benjamin, but with thicker ſcales.

OBSERVATION.

Platina, which reſiſts the action of all other acids, is thus, like gold, diſſolved by aqua regia. The proportion in which theſe two bodies may be combined, according to the uſual method of ſolution of metals in acids, is that here given: but Dr. Lewis ſhews, by the experiment he has reported of another method, that, if the diſſipation of part of the acid be prevented, by performing the operation in cloſe veſſels, with a proper apparatus for collecting the fumes, and returning that part which exhales, on the matter, the proportion of platina may be increaſed by one half.

This property of combining with aqua regia only is one of thoſe, which ſhew that moſt remarkable ſimilarity of nature betwixt platina and gold. The ſolution of platina does not, however, reſemble that of gold, in giving a red or purple ſtain to marble, or animal, or vegetable ſubſtances of a white hue.

EXPERIMENT XXXI.

Precipitation of platina from the ſolution of it in aqua regia.

Take the ſolution of platina in aqua regia; and add to it, copper, iron, tin, zinc, or mercury; and they will cauſe a precipitation of a greyiſh or blackiſh magiſtery; but not of the whole of the platina: as may be perceived, or preſumed, by the colour of the fluid, after their action on it.

Or add lixiviate ſalt, volatile alkaline ſalt, or ſal Ammoniacus; and a red ſparkling powder will be precipitated: but a part of the platina will yet remain diſſolved: as will appear from the yellow colour of the fluid. This magiſtery is not, however, the platina ſeparated from the acid; but either a depart of ſome quantity of it, from the water, ſtill combined with the acid only, or with both the acid and the ſalt alſo: for it appears to be evidently ſaline; as it may be re-diſſolved again in water; giving the ſame yellow colour as the original ſolutions.

Or add the vitriolic acid in a concentrate ſtate; and a duſky magiſtery will be precipitated; which is not re-ſoluble in water.

Or add alkaline ſalts to the fluid, from whence a precipitation of the platina has been made by ſal Ammoniacus, according to the utmoſt power which that ſalt ſingly has on the ſolution; and the whole remaining part of the platina will be departed; the fluid becoming colourleſs.

OBSERVATION.

In the proceſs of the above experiment, it will be found, that tin precipitates a greater proportion of the platina than any other metallic or ſaline body: and, indeed, it ſeems dubious from the report of one of Dr. Lewis's experiments, whether platina may not, by ſome management, be wholly precipitated by tin ſingly. It will be, alſo, found, that mercury ſeems to have the leaſt power in precipitating the platina: as a very conſiderable quantity of it will be diſſolved in the ſolution, before any depart of the platina be made. It appears, likewiſe, that there is a remarkable difference betwixt the precipitations made by alkaline ſalts, and ſal Ammoniacus; and thoſe made by the metallic bodies, or the vitriolic acid: for, in the firſt caſe, the precipitated matter is ſoluble; in the latter not: from whence it may be concluded, that the depart, in the caſe of the ſaline ſubſtances, is rather that of the platina from the water of the aqua regia, by the production of a new compound, formed by ſuch acid and the ſalt added, than from the acid: and it is probable, likewiſe, in the precipitation of the platina, by the vitriolic acid, that it is not departed in a ſimple ſtate; but that it undergoes a precipitation by corroſion, according to the principles laid down page 21. Vol. I. as thoſe of ſilver, zinc, or mercury, from ſpirit of nitre; ſome proportion of both the acids remaining combined with it.

By this variation of platina from gold, in not ſuffering a total precipitation from aqua regia, by the addition of theſe ſeveral ſubſtances, particularly alkaline ſalts, a method is furniſhed of diſtinguiſhing, when platina is combined with gold in ſuch proportions, as not to be perceptible; and which, the great reſemblance of theſe two metallic bodies to each other in moſt of their qualities, prevents from being effected by the uſual methods of aſſaying metals. For, if a ſolution of the compound of them be made in aqua regia, and the alkaline ſalts added, the gold will be wholly precipitated: and it will, afterwards, appear, by the preſence or want of yellow colour in the fluid, whether the gold were free from platina, or allayed by it. The ſame principle, alſo, affords the means of ſeparating platina from gold in large quantities; for, though, as has been obſerved, a part of the platina will be precipitated with the gold; yet, as it is ſubject to be re-diſſolved by water, it may be ſeparated from the magiſtery of the gold, by repeated ablutions: which will not carry off any ſenſible part of the magiſtery of the gold.

EXPERIMENT XXXII.

Combination of platina with the metals.

Take platina, one part; and gold, four parts; and fuſe them together. They will combine perfectly; and the compound will be harder, leſs malleable, and paler than pure gold: but not in a degree much greater than ſtirling gold alloyed with ſilver. If, however, the compound be again fuſed with a flux of nitre, and borax, it will become very pale. Platina reſiſting the vitrifactive power of lead, the diſſolvent power of all the acids, except aqua regia, and the volatilizing power of antimony; while, at the ſame time, it is ſoluble in aqua regia, and capable of combining with hepar ſulphuris, and mercury, in the ſame manner as gold; the compounds formed of it with gold, when the proportion of it is not too great, elude decompoſition, by all thoſe means, that are uſed for the examination of the proportion of alloy of gold, or its purification:

bearing all the teſts; and being, moreover, nearly of the ſame ſpecific gravity with pure gold.—With an equal proportion of gold and platina, the compound is, however, rendered white, loſes all malleability, and becomes, in ſome degree, friable.

Take platina, one part; and ſilver, ſeven. Fuſe them together; and they will combine, ſo long as that degree of heat continues; but, on the gradual abatement of it, they will ſeparate, and the platina will ſubſide by its ſpecific gravity. In order, therefore, to preſerve their union, pour the whole together, while hot, into a broad mold, that the maſs may ſtiffen before any precipitation can take place. This compound will be more hard, but leſs malleable, and white, than pure ſilver: and even a much leſs proportion of the platina will deprave the colour, and diminiſh the malleability of ſilver. A ſeparation may, however, be made, in part, by fuſory precipitation: as the platina will ſubſide on a gradual abatement of the heat. But the compound may be more perfectly analyzed, by parting, through the means of aqua fortis, in the manner before directed in Experiment XII. for the ſeparation of gold from ſilver.

Take platina, one part; and copper, four parts. Fuſe them together; and they will combine; and form a compound of a very pale colour; and leſs malleable than pure copper. If equal parts be combined, the compound will be white; and devoid of all malleability: but to make the union of theſe two metallic bodies, in a greater proportion than one of the platina to three of the copper, it is proper to uſe the ſame expedient as with ſilver. This compound being expoſed to the fire, the platina will be found, in ſome degree, to prevent the ſcorification of the copper: and, being poliſhed, it becomes extremely bright; and is not ſo ſubject to tarniſh in the air as pure copper.

Take of platina, one part; and of lead, twelve parts. Fuſe them together, and they will combine; but not without a ſtronger heat than will liquefy the lead; and form a compound, that will be harder than pure lead; but want its tenacity, and malleability. The colour of this compound will be darker than that of lead, and inclining to purple: which will be increaſed on being expoſed to the air. If a greater proportion of the platina be combined with lead, the compound will be devoid of malleability: and more dark and purple: requiring a correſpondent increaſe of heat, and the expedient before directed in the caſe of ſilver, to the union of the ingredients. Or take platina; and cupel it as before was directed in the caſe of gold, Experiment II: and it will not only reſiſt vitrification, and remain unchanged as gold: but preſerve at laſt a portion, being about the quantity of a fifth part of itſelf, of the lead, from the action of the fire: retaining it combined with itſelf, under any degree or duration of heat; and bringing it back from the liquefied, to a ſolid ſtate, not changed by any degree of heat produced on the principle of culinary fire.

Take of platina, one part; and of tin, four parts; and fuſe them together. They will combine, and a compound will be produced, that will be malleable only in a ſmall degree: and of much leſs brightneſs, and greyer colour, than tin. If equal parts of theſe two metallic bodies be combined; which may be done by colliquatory fuſion, without the expedient neceſſary in the caſe of ſilver, copper, and lead, as there will enſue no ſeparation on the abatement of the heat; the compound will be of a dark grey colour; and ſo looſe in its texture, that it may be ſcraped into a blackiſh powder by a knife. Theſe colliquations may be beſt made under a reducent flux, ſuch as the black flux mixt with common ſalt, or borax, to prevent the calcination of the tin by the acceſs of air: though it will be found, that the platina itſelf, in a conſiderable degree, preſerves the tin from the calcining action of the fire: as the diminution of the quantity will be much leſs than if the tin underwent the ſame degree of heat alone.

Take of platina, and the pureſt caſt iron, each three ounces; and fuſe them together.

They will combine; and form a compound with ſome degree of malleability, and extremely tenacious, when cold, but eaſy to be broken, when heated; and hard: but the colour will be much darker than that of iron. It will take a fine poliſh; and is not liable to the leaſt ruſt on being expoſed for a conſiderable time to the air. If a compound be made of only one part of platina, and twelve parts of caſt iron, it will yet have a conſiderable degree of roughneſs; and be extremely difficult to be broken while cold. If a compound, of one part of platina, and four parts of caſt iron, be cemented for twelve hours; with a compoſition of powdered charcoal, ſoot and aſhes of wood, and common ſalt, (which is Raumur's cement for the converſion of iron into ſteel) it will become ſofter; and more yielding to the file: but it will not be rendered more capable of receiving, like ſteel, an additional hardneſs, on being heated to a luminous degree, and quenched in water; nor acquire any other reſemblance to ſteel.

Take equal parts of platina and braſs; and, having covered them with borax, fuſe them with a very briſk fire in a furnace with a ſtrong blaſt: They will combine together; and form a compound, of a greyiſh white colour, eaſy to be broken; and devoid of malleability: but capable of a very fine poliſh; and not ſubject to be tarniſhed, on being expoſed to the air for ſeveral months.

Take copper, tin, and platina, in the proportion of one hundred parts of platina to thirty four of copper, and twelve of tin; and, having put the mixture into a crucible, and covered it, bring it to fuſion with borax; and the metallic bodies will combine; and form a compound, ſo hard as ſcarcely to be touched by the file; very brittle; of the colour of dull bell-metal; capable of a very find poliſh; and not liable to tarniſh with the air, though expoſed to it in a dry place for ſeveral months.

OBSERVATION.

The following important inferences may be drawn from the ſeveral articles of this experiment.—That gold may be alloyed by platina, without making ſuch change in it, as would be ſenſible, unleſs by extraordinary means, of examination: the common means of aſſaying ſuch gold, as well as thoſe of ſeparating it from other metallic bodies, wholly failing in this caſe; and the platina, ſo combined with gold, ſtanding all the common teſts of the genuineneſs of gold.—That it combines, in ſome proportion, with all the other metals: but that, in the caſe of ſilver, copper, and lead, there ſeems a limitation, or ſpecies of ſaturation; the point of which, as in the inſtances of many other ſubſtances, is variable by heat: as appears from the platina's remaining with the other bodies commixt, while under the action of a ſtrong degree of heat; but ſeparating, and ſubſiding, on the abatement of it. The perfect combination appearing not to extend beyond the proportion of one part of the platina to four of the copper, and lead, and a much leſs quantity with reſpect to ſilver. But this muſt be underſtood of the metals in their ſimple ſtate only: for, in the caſe of braſs, which is a compound of copper and zinc, equal parts of that and the platina remain perfectly combined together; and, in the caſe of the compound of copper and tin, the platina may be perfectly combined with half its weight of ſuch compound: and the colliquation may be made by a leſs degree of heat than is required to fuſe the platina with an equal weight of either of thoſe metals ſeparately.—That platina depraves the whiteneſs of ſilver, tin, and lead;

but of ſilver the leaſt; and lead the moſt: and that it whitens copper, and gold; when combined with them in a large proportion: which is, however, required to be much greater in the caſe of gold than copper.—That it renders all the metals more hard, and rigid; and deſtroys, or diminiſhes their malleability: but in various proportions: tin requiring the leaſt quantity to its being changed by it, and gold the greateſt: but that it gives, nevertheleſs, ſome degree of malleability to crude, or caſt iron, which, by the mineral ſulphur that it contains, is wholly deprived of malleability.—That the compounds, formed by combination with caſt iron, braſs, and a mixture of copper and tin, take a very fine poliſh, and reſiſt all ruſt, and tarniſhing, even though expoſed to the air in a dry room for many months: on which account ſuch compounds are perfectly fit to make plates for mirrors, for teleſcopes, and other ſuch purpoſes; in which application, the platina would, conſequently, be of conſiderable advantage.—That copper being combined with it in a ſmall proportion, is made hard by it, without being injured in its colour or malleability; and is, alſo, rendered leſs ſubject to tarniſh; on which accounts, the copper would be improved by ſuch addition, with reſpect to moſt purpoſes, to which it is applied.

EXPERIMENT XXXIII.

Combination of platina with the ſemi-metals.

Take of platina and zinc, an equal weight; and, having brought the platina to a very white heat, under a flux of borax, add the zinc: and a great deflagration enſuing, the platina will be quickly liquefied, and combined with the zinc. The compound produced, will differ but little, in appearance, from pure zinc; except that it will be of a darker caſt, and bluer. It will, however, be found to want that degree of malleability, which zinc has; but to be harder; and not ſubject to tarniſh; though expoſed ſeveral months to the air in a dry place. If the compound of platina, and zinc, be ſubjected to the action of a ſtrong fire, the zinc will deflagrate, and exhale, till only a certain proportion be left; at which time the fire loſes all its action, on the remaining maſs, even its liquefactive power: and the combined matter can neither bc analyzed, nor fuſed, by any degree of heat producible in furnaces.

Take biſmuth; and treat it in the ſame manner as directed for the preceding compound; giving it the ſtrongeſt heat, by placing it before the nozzle of the bellows: and the conſequence will be the ſame as in the caſe of the preceding; the platina retaining a proportion of the biſmuth, which cannot be driven off; and the maſs becoming incapable of being liquefied, by any force of heat.

Take platina; and treat it in the ſame manner, as in the foregoing articles, with zinc and biſmuth, with crude antimony or regulus of antimony: and the conſequence will be the ſame: the platina fixing, at laſt, a portion of the antimony; and defending it from the effects of heat.

OBSERVATION.

It may be concluded from the ſeveral articles of this experiment; that as platina combines, in ſome proportion or other, with all the metals, ſo it does, likewiſe, with all thoſe ſemi-metals, which are, at preſent, in uſe: and, as it will be ſhewn in the next following experiment, that it combines, alſo, with mercury, it, conſequently, has a commenſtruative attraction with all the metallic bodies generally known. It appears, alſo, that it reſiſts the ſcorifactive, and volatilizing power of zinc, biſmuth, and antimony; though the laſt is reſiſted by no other known ſubſtance than gold: and that it, moreover, preſerves a certain portion of all of them, as well as of the metals, when combined with it, from the action of heat with reſpect to every known effect. It follows, therefore, that, whenever gold is alloyed by platina, both the aſſay, and the reſeparation of gold in quantity, muſt be made on different principles from thoſe, on which the common methods of treating gold in either of theſe intentions is founded: and that, conſequently, the eſtabliſhment of ſome other effectual method, in a certain and eaſily practicable manner, is, at preſent, the moſt important object of the experiments on this extraordinary ſubſtance.

EXPERIMENT XXXIV.

Combination of platina with mercury.

Take of platina one ounce; and of pure mercury ſix ounces. Rub them for ſome time, with a little common ſalt, and water, to which a few drops of ſpirit of ſalt are added, in an iron mortar. The platina, and mercury, will commenſtruate, and form an amalgama: in which though it be not ſo perfect as that of gold or ſilver, the platina is nevertheleſs ſo combined with the mercury,

cury, that part of it may be poured off from the maſs, with part of the mercury, that will remain fluid; and will even paſs with it through leather: as will be found by exhalation of the mercury; which will leave the platina in the form of a black powder.

Or take one part of platina, and four parts of lead; and having combined them, by fuſory colliquation, and ſuffered them to grow cold, as much as is conſiſtent with their liquefaction, pour them ſlowly into three times the weight of quickſilver, previouſly heated till it fume. An amalgama will be ſo produced, of a very dull colour; and which on being expoſed to the fire will ſwell and leap about, even though the heat be leſs than will exhale the mercury. On conſtant rapid agitation with water, in a mill, for a week, this amalgama may, however, be brought to look bright and uniform: and will then ſuffer the mercury to exhale freely from it without ſuch agitations.

Or take platina; and combine it by colliquation, with twice its weight of gold:

and having formed the compound into thin plates, by gentle percuſſion with a hammer, after being well nealed, throw it heated red hot into boiling mercury. Triturate it then with water; and the platina will be ſeparated in the form of a black powder: which being waſhed off; on the repetition of the triture, a ſecond quantity will be obtained; ſucceeded on the perſuing the ſame means, by others, but in leſs proportion, till the whole of the platina be thus recovered: the gold remaining in an amalgamous ſtate with the mercury, in the ſame manner, as if they had been combined ſimply.

OBSERVATION.

It appears by the ſeveral parts of this experiment, that platina may be perfectly amalgamated with mercury: notwithſtanding Mr. Scheffer, in his Memoirs to the Royal Academy of Sweden, has aſſerted the contrary; and that moreover it has a ſuperior degree of attraction, with regard to it, to any other metallic body: ſince it not only departs lead from it; but even gold itſelf; though lead is of the higheſt rank in this ſeries of attraction, next to gold and ſilver. This principle ſeems, therefore, to promiſe the means of ſeparating platina from gold, with certainty; and without any loſs of either ſubſtance; and conſequently to afford a method both of aſſaying gold ſo allayed, and of parting it from the platina, even where the quantities are large.

EXPERIMENT XXXV.

Separation of gold from platina, by various means.

Article I. Take the compound of gold and platina; and make a ſolution of it in aqua regia, according to the manner directed in Experiment IV. Mix gradually, with this ſolution, a ſaturate ſolution of common green vitriol; adding freſh quantities ſo long as any turbidneſs is produced: and the gold will, by this means, be departed from the aqua regia; and ſubſide. When the ſediment is perfectly formed, decant off the ſupernatant fluid; and, having waſhed the magiſtery with ſeveral ſucceſſive quantities of water, ſeparate ſuch part of the laſt quantity, as cannot be poured off clear, by putting it into a paper filter: and paſs afterwards ſome freſh water through the filter, and matter remaining in it. Let the paper be then dried; and afterwards, having put it into a crucible, with a mixture of nitre, pearl aſhes, and a little borax, fuſe it; and the gold will liquefy into a pure maſs.

Article II. Or in the place of the ſolution of green vitriol, uſe lixiviate or volatile alkaline ſalts; and the gold will be precipitated, together with part of the platina: which laſt, nevertheleſs, being yet combined with the acid in a ſaline form, may be ſeparated from the magiſtery of the gold by repeated affuſions of water. But care muſt be taken, that this ablution be effectually performed, before the magiſtery of the gold be dried; as well to take away its fulminating quality; as to free it from all the platina, which was precipitated along with it.

Article III. Or add alcohol copiouſly to the ſolution of any compound of platina and gold; and the gold will gradually riſe in a ſhining pellicle, or ſcum, on the ſurface of the fluid: but afterwards by degrees ſubſide to the bottom; though as a part of the platina will be apt to chryſtallize, and conſequently be commixt with the precipitated gold, a careful ablution by water, in order to the re-diſſolution, and ſeparation, of ſuch part of the platina, is neceſſary.

Article IV. Beat the compound of the gold and platina into thin plates, by gentle percuſſion with a hammer; if the proportion of the platina and gold be ſuch as admit of it; but if not, flux it with ſuch an addition of gold, as will render it ſufficiently malleable to undergo this operation; which may with due care be performed on it, when the quantity of platina in the compound does not exceed one third of the whole. Treat theſe plates as is directed in the laſt article of Experiment XXXIV; and the amalgamation and ſeparation by triture being made, as there deſcribed, exhale, or diſtil off the mercury: and the gold will be found in a pure ſtate.

In order to the more advantageous performance of any of theſe operations, the proportion of the platina, combined with the gold in any particular compound, may be, in ſome degree, previouſly diſcovered, by fluxing it with nitre and borax; which render the colour of the compound pale, according to the greater quantity of the platina contained in it: and this may, in ſome degree, be a ſubſtitute for the uſe of the touchſtone; that does not avail in this caſe.

OBSERVATION.

The method propoſed in the firſt article, which is founded on the authority of Mr. Sheffer's experiments, as communicated by him in his ſequel to the memoir given on this ſubject to the Royal Academy of Sweden, ſeems to promiſe the moſt eaſy, and a very effectual, manner of ſeparating platina from gold; either where it may be required to part larger quantities; or in the view of making aſſays. Mr. Sheffer adviſes to ſubjoin an amalgamation to this proceſs; under the notion, that platina will not commenſtruate with mercury: as he has indeed aſſerted, that on trials, made even with the addition of aqua regia, platina could not be amalgamated with mercury. But it appears by Dr. Lewis's account, that by meer trituration with water, the platina was taken up, by mercury, in ſuch manner, as even to paſs with it through leather: and the dependance, therefore, on the operation, for the more perfect ſeparation of theſe ſubſtances, through amalgamation of the gold by the common method, would be extremely fallacious; as it is indeed needleſs, alſo, if the ſolution of the green vitriol added make no precipitation of the platina, as Mr. Sheffer himſelf affirms.

The method propoſed in the ſecond article is more troubleſome, and more dubious with reſpect to its efficacy, than the firſt: as the rediſſolution of the platina precipitated, is more difficult than the meer ablution of the ſalts in the firſt. It ſeems, however, practicable, in caſe of neceſſity, to free the gold in a very great degree from the platina by this means: if the trouble requiſite to perform the proceſs be taken.

The third method is alſo more uncertain than the firſt; as well as more tedious; the ſeparation of the gold by alcohol from the aqua regia, requiring a conſiderable length of time; and the ſame ſubſequent ablution, as in the caſe of the precipitation with alkaline ſalts, being neceſſary, perhaps, in a great degree, to extract ſuch of the platina, as may chryſtallize, from the magiſtery of the gold.

The laſt method is propoſed, by Dr. Lewis, as a proper means for the examination of gold allayed with platina; and ſeems to be very effectual: but it is much more complex and troubleſome, as well as more difficult to be executed with due certainty, than the firſt: which would, therefore, much better anſwer the purpoſe, if, on further trials it ſhall appear, that the green vitriol will not precipitate any part of the platina: for, if it ſhould prove, that the gold be not wholly freed from the platina by once performing the operation, a repetition, which may be performed with very little expence or labour, could not fail of fully anſwering the end.

EXPERIMENT XXXVI.

Separation of mercury from other metallic bodies, or mineral ſulphur, combined with it.

Take the compound of mercury and any other metallic body; and, having put it into a ſmall retort of a long figure well coated with lute, fix the retort in a proper furnace, ſo that the orifice of the neck may be almoſt perpendicularly depending downwards. Place a receiver full of water, in ſuch manner under it, that the end of the neck of the retort may be immerſt in the water, in order to which, the neck of the receiver ſhould be wide enough to let the neck of the retort paſs into it without twiſting it. Let the fire be then kindled; and raiſe it ſo that the mercury may be made to diſtil. The fumes paſſing into the neck; and being either condenſed there, or in the ſurface of the water, will be collected at the bottom of the receiver. It may be eaſily diſtinguiſhed, when the whole of the mercury is come over by the ceſſation of the hiſſing noiſe, which it makes, while the diſtillation continues, by falling hot into the water.—Or if the mercury be combined with mineral ſulphur, either in the form of Æthiops mineralis, or cinnabar, let quick lime, or iron filings, or a mixture of both, be well ground, with the matter containing the mercury, in proportion to the quantity of the mineral ſulphur abounding in it: and let the mixture be then ſubjected to diſtillation, as in the preceding article. The mercury will in this operation be departed from the mineral ſulphur, by the ſuperior attraction of the lime, or iron, on ſuch ſulphur: and, being thus ſet free, will be raiſed in fumes, and brought over, in a pure ſtate.

OBSERVATION.

The firſt method is uſed for the recovery of mercury from gold and ſilver, when combined with it, either with the view of extracting the gold, or ſilver, from ores, or foſſile compounds that contain them; or of aſſaying or refining them, when allayed by art: as alſo for the ſeparation of the mercury from tin or other metallic bodies with which it is commixt for the ſilvering looking-glaſſes, or on other occaſions: as alſo for the purification of it for medicinal uſes, the making barometers, or other ſuch purpoſes where ſtrict purity is required.

Where large quantities of the mercury are to be freed from other metallic bodies, the operation may be much more eaſily performed, in the following manner, in an iron veſſel, than in either glaſs or earthen retorts. Let the iron veſſel be of the form of a flattiſh pan, with a cover ſoldered to it, and perforated in the middle, with a large hole: into which a ſtoppel ſhould be made to fit, by ſcrewing into it: and in the ſide of the veſſel, juſt under the cover, a gun barrel, or iron tube, ſhould be alſo ſoldered in an oblique poſition, ſomewhat inclining downward; the ſide of the veſſel alſo ſhould be ſo perforated, that the cavity of the tube may communicate with that of the veſſel; and the lower end of the tube bent for ſome inches, ſo that it may point downward. The mercury being put into this alembic, it may be placed on any common fire; and a receiver or any veſſel full of water being placed under the tube, ſo that the end of it may be immerſt in the water, the diſtillation may be performed with great convenience; and when the whole of the mercury at firſt put in is brought over, the veſſel may be immediately charged with a freſh quantity, by unſcrewing the ſtoppel. But this cannot be practiſed where the mercury is to be ſeparated from cinnabar; unleſs a copious quantity of lime be thoroughly commixt with it: for the mineral ſulphur would, otherwiſe, commenſtruate with the iron, of which the veſſel is conſtructed; and corrode it through the whole ſubſtance.

EXPERIMENT XXXVII.

Amalgamation of mercury with other metallic bodies.

Take a ſound crucible: and having rubbed its interior ſurface with chalk, heat it luminouſly hot. Take it then out of the fire; and put into it an ounce of gold or ſilver, either in the form of thin plates, or granulated; and two or more ounces of mercury. Stir the mixture briſkly about; and the gold or ſilver will combine with the mercury; and form a kind of paſte-like maſs called an *amalgama*. If it be deſired, to have the amalgama of a more thick conſiſtence, ſtrain the matter through a piece of ſhamoy leather: but in that caſe, the mercury will be charged with ſome quantity of the metal; though not near ſo great a proportion, as before it was ſtrained.

Take of the filings of lead, and tin, one ounce, and of mercury two ounces; and rub them together, without heat. They will combine; and form an amalgama: but the amalgamation may be quicker made, by adding the mercury to the metals liquefied by heat.

Take zinc, or biſmuth, beat into ſmall parts, or granulated; and treat them, as above directed in the caſe of gold, or ſilver: but the combination of the mercury, and biſmuth, is not perfect: as the biſmuth ſeparates again gradually, from the mercury: riſing to its ſurface in the form of a powder. In the caſe of the zinc, there appears to be ſome kind of decompoſition from the action of the mercury: as a brown powder is departed, during the combination of the two bodies: but whether this be a proper part of the zinc itſelf, or ſome heterogeneous body diſſolved with it, is not hitherto decided; though it merits examination.

OBSERVATION.

Lead being combined with biſmuth, by fuſion, is more readily combined with mercury than when pure: but the ſpontaneous ſeparation of the biſmuth is nevertheleſs made in the ſame manner, as if it had not been united with the lead.

It is ſaid, likewiſe, that an amalgama may be made of copper, and braſs, with mercury: but, as I have found the methods given for it have failed of producing the effect in any perfect manner, I have omitted the enumerating them in the regular experiments. It is ſaid, however, that it may be done by the following means. Firſt, by long trituration of the magiſtery of the copper, precipitated from any acid by iron, with the mercury, in an iron mortar, hot water being added: ſecondly, by adding the mercury, diſſolved in aqua fortis, to the ſame magiſtery of copper: and thirdly, by diſſolving the copper in the vitriolic acid, and triturating it with an amalgama of zinc; repeated quantities of water being added, and poured off. Iron is, likewiſe, pretended to be amalgamated with mercury, through theſe means. Pour a ſolution of blue or Roman vitriol on filings of iron: and when the copper precipitated on the ſurface of the particles of iron, by the ſuperior attraction of that metal on the acid of the vitriol, has changed them to the colour of copper, pour three times the weight of the iron of mercury: and (as is ſaid) an amalgamation will be inſtantly effected: which, nevertheleſs, by trituration with water in a marble or ſtone mortar, will be ſoon deſtroyed; the iron ſeparating in the form of a powder. But where the mediation of diſſolving acids is thus uſed, a part of them remaining combined with the metallic bodies, the union of the mercury with ſuch metallic bodies cannot be properly called a combination of the mercury with them, but with a compound of them, and the acids employed: and the proper qualities of an amalgama fail to be produced.

Regulus of antimony, is, likewiſe, amalgamated with mercury, according to the report of Henckel, by the following method. Boil mercury, with a copious quantity of water, in an iron pot; and add to them regulus of antimony fuſed by heat, in the proportion of a third part of the weight of the mercury; uſing a gentle trituration for the ſpace of a minute; but not longer: for, if it be continued, the union of the mercury with the antimony, which will then have taken place, will be again ſuperſeded; as it will alſo, if the compound be, afterwards ſhaken briſkly in a veſſel with water: or even kept for ſome time at reſt. This union may, therefore, be more properly eſteemed a mechanical commixture of the regulus, liquefied by fuſion, with the mercury; than a menſtrual combination of the two ſubſtances: though it is given by Henckel, the firſt promulgator of it, and others after him, as amalgamation correſpondent to thoſe of gold, and ſilver, with mercury.

The amalgamation of gold, or ſilver, is practiſed, as was before obſerved, for the ſeparation of them from ore, or other bodies, with which they may be combined in a mineral ſtate: as alſo from other ſubſtances, with which they may be commixt in the ſtate of filing, or powder by any other means. It is, likewiſe, in the caſe of gold, conſtantly performed with the view of gilding ſilver, or copper; the amalgama being ſpread on the ſilver or copper; which is previouſly embrocated with ſpirit of nitre; and the mercury afterwards driven off by the application of due heat; leaving the gold cohering to, and covering, the ſurface of the ſilver or copper. The ſame was formerly practiſed with ſilver on copper: but at preſent that method of ſilvering is diſuſed; the like effect being produced with much leſs expence and trouble, by means of leaf ſilver. The amalgamation of tin is practiſed, for the ſilvering plates of glaſs for mirrors; which is done by ſpreading the amalgama on thin ſheets of tin placed on a flat table of marble, and laying the glaſs over them; and afterwards cauſing a coheſion of the tin and mercury to the glaſs by preſſure, through the means of weights put upon the reverſe of the glaſs. This operation is called *foliation.*

EXPERIMENT XXXVIII.

Combination of mercury with acids.

Take of mercury, and oil of vitriol, each an equal quantity; and, having put them into a retort, diſtil with a gradual heat of ſand, till the fumes ceaſe to come over, except in a ſmall degree. Let the fire then ex-

extinguiſh; and, the retort being broken, the mercury will be found combined with the acid, in a hard white maſs: which is but in a very ſmall degree ſoluble in water.

Take of mercury, and pure ſpirit of nitre, equal quantities; and, having put them into a glaſs body, ſet them to digeſt in a gentle heat; and the mercury will be gradually diſſolved: but will, if the heat be not ſtrong, form chryſtals at the bottom of the body.

Take the dry maſs of the vitriolic acid, and the mercury, or the ſalt of the ſolution in ſpirit of nitre reduced to dryneſs by evaporation; and having commixt them, by grinding in a marble or glaſs mortar, put them into a ſmall mattraſs; and place it in a ſhallow ſand bath, ſo that about one half of it may be within the ſand. Sublime then with gentle heat: and the vitriolic acid, or the ſpirit of nitre, leaving the mercury with which it was combined, will commenſtruate with the natron or alkaline part of the ſea ſalt; departing the proper acid of that ſalt, by its ſuperior at-

attraction: which acid, being thus ſet free, will commenſtruate with the mercury ſeparated from the vitriolic acid: and by this means, two new compounds will be formed: that of the ſpirit of ſalt and mercury riſing with the heat, and collecting againſt the upper part of the glaſs in the form of a ſemi-tranſparent chryſtalline cake, in which ſtate it is called *corroſive mercury ſublimate*; and that of the vitriolic, or nitrous acid remaining in a maſs at the bottom in the form of Glauber's ſal mirabile, if of the firſt of thoſe acids; or the quadrangular nitre, if of the other. The corroſive ſublimate being ground, and commixt with an additional quantity of mercury, in the proportion of nine ounces to twelve, ſuch additional quantity may be alſo combined with the ſpirit of ſalt in the ſublimate, by another ſublimation: in which ſtate, the ſublimation being again repeated twice, it is called *mercurius ſublimatus dulcis:* but if the ſublimation be afterwards, again three times repeated, it is called *calomel.*

OBSERVATION.

The vitriolic acid will not diſſolve, but only corrode, mercury: nor can it be made to combine at all with it, unleſs when in a very concentrate ſtate; ſuch as is produced in the firſt operation of this experiment, by diſtilling off the phlegm. This is frequently performed for the preparation, for medicinal uſe, of the turbith mineral: which is a compound of the mercury and vitriolic acid, firſt treated as here directed; and then, being freed from as much of the acid as can be expelled by the ſtrongeſt heat of a ſand bath, waſhed in water; which inſtantly turns the white maſs into a bright yellow. The combination of the vitriolic acid is, likewiſe, made in this manner, by thoſe who are in the ſecret for the moſt advantageous method of preparing the corroſive ſublimate, according to the directions given in the laſt article of this experiment.

The combination of mercury with ſpirit of nitre is, likewiſe, practiſed for medicinal purpoſes; in order to the preparation of the *red precipitate* (as it is improperly called); which is the ſalt, formed by the combination of the mercury with the nitrous acid, imperfectly calcined in a crucible with a moderate degree of heat, by which treatment, it aſſumes the appearance of a red ſparkling powder: but the quality of ſparkling not being the conſtant reſult of this operation, and yet requiſite in order to its officinal perfection, a very ſmall quantity of ſpirit of ſalt, one dram to ſixteen ounces, is ordered by ſome to be added to the ſpirit of nitre; under the notion, that it produces this quality in the precipitate. The ſolution of mercury in ſpirit of nitre is, alſo, ordered to be made by the Pharmacopeia of the college of Edinburgh, for the preparation of the ſalt formed by it, which is there erroneouſly called the *calx mercurii:* and directed, likewiſe, to be uſed for the preparation of the corroſive ſublimate.

The combination of ſpirit of ſalt with mercury, is conſtantly practiſed for the production of the corroſive ſublimate, but it cannot be effected, unleſs that acid be in a very concentrate ſtate; which, on account of its great volatility, when not diluted with water, is not to be produced, but by complex, or troubleſome methods. Inſtead, therefore, of the ſimple ſpirit of ſalt, the ſea ſalt itſelf is uſed, together with one of the other acids of ſuperior attraction; by which, being let looſe, it may be at liberty to act on the mercury: and in order to the more effectual commixture, it is neceſſary that ſuch other acid ſhould be brought to a ſolid form, either by combining it with the mercury, or ſome other ſubſtance, which it may be made to quit in the operation. In the former method of preparing the mercury ſublimate, it was, therefore, practiſed to uſe green vitriol, nitre, and ſea ſalt, added to the mercury: which, according to the explanation given of their action on each other in this view, p. 17, Vol. I, anſwer the ſame end, as if either the vitriolic, or nitrous, acids were employed in their ſimple ſtate; but render the proceſs much more troubleſome and expenſive, than if oil of vitriol be uſed, according to the proceſs of this experiment. The combination of an additional proportion of mercury to the corroſive ſublimate, with the repetition of the ſublimation for three or more times, is, likewiſe, conſtantly practiſed, for the preparation of the *mercurius ſublimatus dulcis*: or *calomel.*

EXPERIMENT XXXIX.

Precipitation of mercury from the ſolution of it in acids.

Take corroſive ſublimate; and diſſolve it in about twelve times its weight of hot water; and then add to it, gradually, a ſolution of lixiviate ſalt, ſo long as the addition of a freſh quantity produces any change. The mercury, departed from the acid, will give, firſt a white turbidneſs to the fluid; which, on the addition of a further quantity of the lixiviate ſalt, will be changed to an orange colour; but, if the proportion of the ſalt be ſufficiently great, the precipitated powder will turn, at laſt, blackiſh; though, by the due limitation of the proportion of the lixiviate ſalt, it may be kept either of a perfectly white colour, or any of the intermediate teints, betwixt white and orange.

Or take the ſolution of mercury in ſpirit of nitre, according to the preceding experiment; and add to it, gradually, a ſolution of ſea ſalt: and the mercury will be precipitated; but not in a ſtate ſeparated from the nitrous acid, but combined, both with ſome proportion of that, and of the ſpirit of the ſea ſalt departed by the nitrous acid.

OBSERVATION.

The precipitation of mercury from ſublimate is practiſed in the pharmaceutic chemiſtry for the preparation of what is called, by the college of phyſicians of London, the *white precipitate of mercury*: but the ſame ſubſtance is, by the college of Edinburg, called the *ſweet precipitate of mercury*, to diſtinguiſh it from the other kind precipitated from the ſolution of the mercury in ſpirit of nitre, by a ſolution of ſea ſalt; for which they have retained the former name of *white precipitate*.

The precipitation from the ſolution in ſpirit of nitre is not effected by a departure of the mercury from the acid by the ſea ſalt added; but is a precipitation by corroſion; ſuch as was before explained in the introduction, and exemplified in the caſe of ſilver, in the production of luna cornea; and in other inſtances: and this method is more frequently practiſed than the other with corroſive ſublimate; from which it differs in producing a precipitate partaking of a ſaline nature, that renders it gently eſcarotic; on which account it was formerly uſed in external applications; and is ſo, indeed, at preſent, by the farriers. In this view, therefore, the ſweet kind is not a proper ſubſtitute for the other.

EXPERIMENT XL.

Combination of mercury with mineral ſulphur.

Take mercury, and mineral ſulphur, putting of each an equal quantity; and triturate them together, till they combine; and form a black powder.

Or put mineral ſulphur into a crucible, and heat it; taking care, that it do not catch fire. Being fuſed, add gradually to it, any quantity of mercury, not leſs than one third of the ſulphur; and ſtir them well with a tobacco-pipe: and if the ſulphur flame, by the heat excited in the commenſtruation of theſe two ſubſtances, which is attended with a ſtrong effervefcence, cover them with a wet cloth. Powder the matter; and, having mixt the whole of it well together, put it into a coated body, tapering towards the top; and, having fixt the body in the naked cavity of a proper furnace, ſo that only ſomewhat more than one third may be expoſed to the fire, and covered the mouth of the body with a bit of tile or glaſs, but without lute, ſublime the contents with as ſtrong a degree of heat as can be given, without driving the fumes out of the mouth of the body: avoiding, nevertheleſs, by taking off the tile or glaſs, and making a paſſage with the end of a tobacco-pipe, that the vent may not be wholly choaked up, leſt the elaſtic vapour burſt the body. When the whole is ſublimed, which may be known by the abatement of the heat in the upper part of the body, notwithſtanding the fire be ſtill of the ſame degree, let the whole grow cold: when, having broken the body, the compound of the mercury and ſulphur will be found incruſted on the upper part of the glaſs, under the appearance, while intire, of a ſemi-metal, formed of grey ſhining needle-like ſtria; in which ſtate it is called *cinnabar*; but, on being pulverized, of a bright red colour.

OBSERVATION.

The firſt manner of combination, as alſo that part of the ſecond which regards the combination of the mercury and ſulphur by fuſion only, are practiſed with medicinal views, for the preparation of the *Æthiops mineralis*: which, as was above obſerved, is the compound of mercury and ſulphur formed by cotrituration; or by colliquation through heat, with a ſubſequent comminution.

The other manner is, likewiſe, in conſtant uſe, for the preparation of cinnabar for medicinal purpoſes: to which it is applied under the name of *factitious cinnabar*; to diſtinguiſh it from the mineral compound of the two bodies called *native cinnabar*: of which a kind found in the ſhops, and ſaid to be brought from the Eaſt, greatly reſembles it. But it is doubted by ſome, who have made very ſtrict enquiries into this matter, whether there be any native cinnabar ſo pure, as to reſemble the factitious; and whether, conſequently, the kind brought from the Eaſt-Indies be not really factitious: as all the ores, or mineral compounds of mercury and other ſubſtances, found in this part of the world, wholly want the bright red colour, which the factitious, or the pretended native cinnabar of the ſhops, are indued with. The proceſs is, likewiſe, conſtantly performed with a view to the producing *vermilion* for painting; which is, indeed, only the factitious cinnabar, prepared in ſuch manner as is moſt advantageous to the red colour; and finely levigated. But in this caſe it is ſublimed in earthen bodies of the form of an egg; and, afterwards, firſt ground in a mill; and then on a marble or porphyry ſtone.

The Æthiops mineral, and the factitious cinnabar, as well as the native, may be decompounded, by the means directed in Experiment XXXVI. iron, lixiviate ſalt, or quicklime being added.

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